PETROLEUM REFINER

SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

December, 1945
Volume 24, No. 12

A Gulf Publishing Company Publication
EDITED MONTHLY AT HOUSTON, TEXAS

GRADY TRIPLETT
Editor

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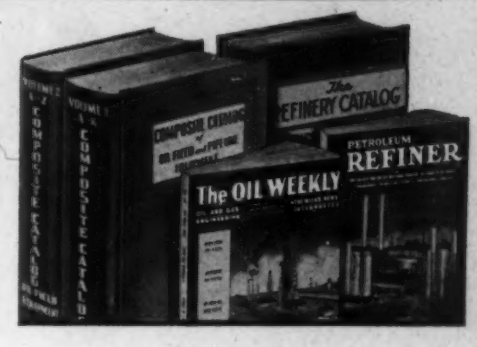

SPECIALIZED OIL JOURNALS

Published by
THE GULF PUBLISHING COMPANY
OFFICE OF PUBLICATION
3301 Buffalo Drive, Houston, Texas

R. L. DUDLEY, *President*
A. L. BURNS, *General Manager*
J. KENT RIDLEY, *Managing Editor*
TOM W. NELSON, *Advertising Manager*

NEW YORK: Room 523, 250 Park Avenue, Dick Swinsky, Manager.

CLEVELAND: 1010 Euclid Avenue, Robert B. Farson, Manager.

CHICAGO: 332 S. Michigan Avenue, H. G. Fitzpatrick, Manager.

LOS ANGELES: 426 W. W. Wilson Building, Huntington Park, California, J. W. Curts, Manager.

TULSA: 1304 Hunt Building, J. F. Carter, Jr., Manager

FT. WORTH: 203 W. T. Waggoner Building, H. H. King, Manager.

Single copies 35 cents (except special issues). Subscription price, domestic and foreign, $2.00 a year; 2 years $3.00; 3 years $4.00. Entered as second class matter June 16, 1923, at the post office at Houston, Texas, under act of March 3, 1879. Advertising rates on application.

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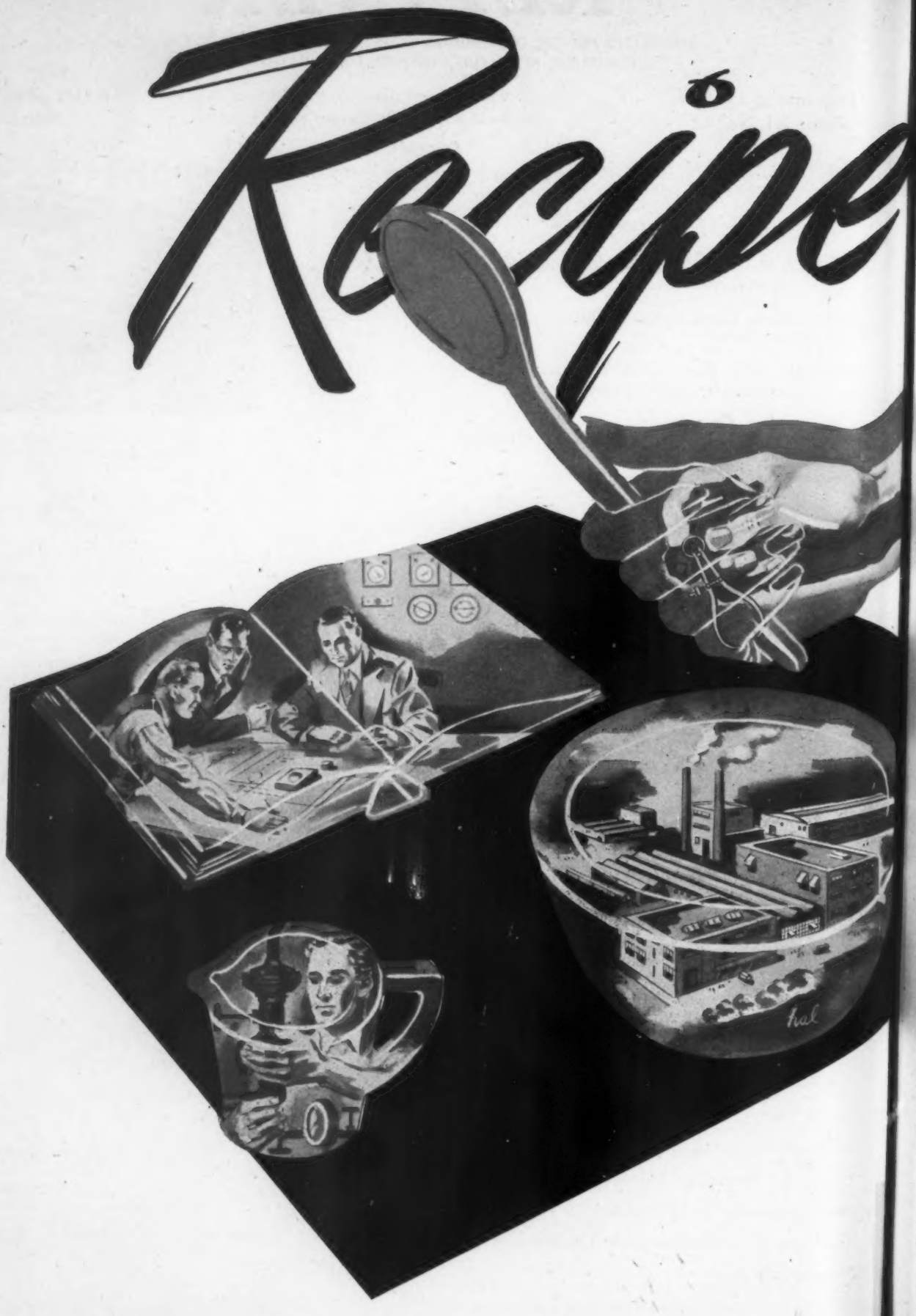

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VOLUME 24, NO. 12 DECEMBER, 1945

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A GULF PUBLISHING COMPANY PUBLICATION

THE LOOK BOX

ALL indications are that a national research board will be set up by the federal government. Its form is yet uncertain, with two bills before a committee. One issue concerns the method of selecting a board. Another concerns the disposition of patents that come out of research done or sponsored by the federal bureau.

National Research

Success of research by governmental sponsorship during the war gives the peacetime proposal a backing that will bring the new bureau into existence.

Creation of such a board will have such widespread influence on men in the refining industry that they should study all proposals and analyze all testimony in support of the proposals.

IN CLOSING down its butadiene-from-alcohol plants Rubber Reserve Company has done more than select its cheaper source of a chemical rubber ingredient. It centers attention on a matter of national interest. The oil industry has an interest no greater than others, despite the fact that refinery gases have been singled out for butadiene raw material. These gases have other and more profitable uses in refining, and left to the guidance of economics the refiner would use them for these purposes.

Rubber Policy

The matter of national interest, however, permits no such solution. The question—what is the long-range rubber program—cannot be answered so readily. What happened with the fall of Singapore is evidence that this country again could be put to the task of devising a source of rubber products. Having done it once, no one doubts that it could be done again. But no such vital matter should be left in a status of going back to pick up a product that had not reached satisfactory status.

It is known that GR-S, the all-purpose chemical product, is not the equal of natural rubber for automobile casings. The national policy should provide for a continuing research and a continued plant operation to bring GR-S or some other chemical product into equality with natural rubber. An all-purpose elastomer should be under constant improvement in the United States. However remote the need, this country should never come up against a day of laboratory turmoil and plant design without benefit of pilot-plant operation.

The simplest solution is outright subsidy by government. The objection to this is that subsidized programs seldom keep pace with scientific possibilities. Given plants to operate, the disposition is to operate them as they exist. But chemical rubber needs competition. It should be put up against accomplishments in natural rubber processing.

Despite the hazards and fears of cooperative action, it would seem desirable to permit the several industries to form a pool for operating some part of the GR-S rubber industry. This rubber could be used solely by the military and kept in constant competition with natural rubber in civilian use. Petroleum, chemical, rubber are the industries which could combine resources and share losses with the books of the pool open to the Department of Justice. Demands of the military for satisfactory casing rubber would be the goading influence over such a combination.

There need be no concern over specialty products. Butyl rubber, neoprene, Thiokol and other products will gain wider distribution through economic processes. They can be so made that they

F A M O U S

Caustic Comments

When invited to attend a dinner party given by a snobbish socialite, the late John Barrymore replied in caustic tones, "I'm frightfully sorry I won't be able to come, Mrs. Bore. I have a previous engagement which I shall make just as soon as I possibly can!"

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are superior and their higher costs are thus justified. In time hundreds of other special elastomers will gain a place by competition. Their development will benefit any program to maintain and improve an all-purpose product.

But the welfare of the United States demands an aggressive policy that will assure a constantly improved all-purpose rubber. Whether it has government subsidy or not, it should have the permission of government.

Areas of Confusion

TO MANY bewildering issues have been injected into the strike controversy that the simple proposition of higher pay for fewer hours has been lost in the attending confusion. To the observer there is an inclination to suspect that the diversion is offered because the main issue will not support scrutiny.

What the matter amounts to is that one group wants a wage increase, so consistently placed at 30 percent that the figure has become a standard in bargaining and in strike justification. Still, few men come out simply and call for that wage increase simply to assure men that much more money. The figure is offered as a means of assuring a necessary volume of purchasing power. Thus a wage has ceased to be an item in a family budget; it is the motive power in national economy. Furthermore that increase is frequently demanded along with another proposition that retail cost of merchandise be held at existing price levels.

Likewise those who watch pay rolls desert the matter of what business can pay and contend that wage increases of such proportion should not be granted for the reason that more money in the hands of spenders will feed the flame of inflation.

The simple truth is that neither side is primarily concerned about the state of the nation in these salary disputes. Men want more money for their work; other men do not want to grant it. There is nothing harmful or inconsistent in that. Men's wants have been clashing over these simple matters for ages.

What is novel and confusing is the bedlam of holding price ceilings, preventing inflation, assuring a healthy national income, meeting tax requirements and a score of other propositions that keep the wage question in the background. There is novelty in the proposition that a wage is justified if a corporation has funds for paying it. Also consider the approach of willingness to accept part of a wage increase, then leave further increase to arbitration.

Perhaps the last word in novelty is the legislative proposal that men be forced to accept arbitration. When men come to the decision of a strike they have accepted something more vital than defiance of statute, for lack of wages means less food and clothing. When men are willing to take a chance on that, they will take a chance in defying the law.

Perhaps it is useless but someone should inform lawmakers that arbitration is not encouraged by compulsion.

As the year ends confusion is the expanding element in industrial discord. What men want is being hidden by what they are saying.

Another Obligation

PERHAPS men of scientific accomplishments should assume responsibility for the consequences of their achievements. The observation is based on the plight of spiritual stagnation in an era of technical advancement. From the laboratory and the factory have come the means of more abundant living. Still, it is discouraging to realize that men have adapted so little of this advancement to their own benefit.

Only a few months have passed since the last enemy of the United Nations stood on shipboard and waited for orders to sign. Thus the last obstacle was removed for the establishment of peace. But the days of Peace on Earth approach without evidence of mankind moving in that direction.

Evidently the philosopher, the prelate and the business man do not know how to adapt invention to comfort and abundance.

It will do no harm if the man of science takes a little time away from his laboratory and lends a hand at teaching other men how to live in company with an improving physical world. Certainly the chemist can do no worse than the teacher and the parent have done.

This subject had brilliant portrayal by General Douglas MacArthur, who spoke to the people of the United States from Tokyo Bay and observed:

"It is of the spirit if you would save the flesh."

Our Real Employers

BEFORE the Service Clubs of Chester, J. Howard Pew, president, Sun Oil Company, made this point:

"All of us here in this community—managers and workers alike—have tried to be mindful that only through more efficient production can we improve our lot. We have been mindful, too, that our customers are our real employers, and that we are sure of our jobs and our wages only so long as we serve those customers with improved products at prices which they are both willing and able to pay. We know that it is only those companies that produce the most goods per worker that can pay high wages and continue to exist."

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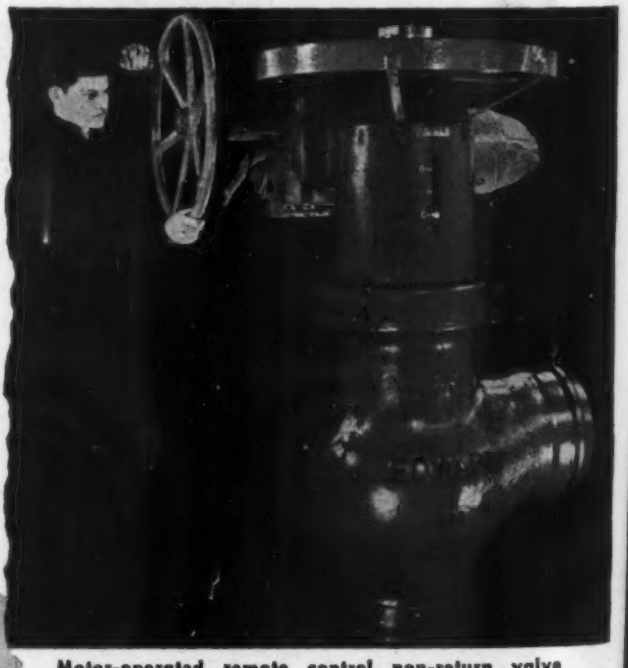

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Method for Predicting Phase Equilibrium Constants

C. G. KIRKBRIDE, Professor of Chemical Engineering
A. and M. College of Texas, College Station, Texas

THIS paper presents an empirical method for calculating the phase equilibrium constants of hydrocarbons which appears to give results in somewhat better agreement with observed values than any previous method published. An empirical correlation for fugacity coefficient (fugacity divided by absolute pressure) has been developed which permits reasonably accurate predictions of phase equilibrium constants up to pressures of 2000 to 3000 Psia. The empirical fugacity coefficient is correlated with reduced pressure (absolute pressure of system divided by absolute critical pressure of component) and reduced temperature (absolute temperature of system divided by absolute critical temperature of component).

Frequently the chemical engineer encounters phase equilibrium calculations with hydrocarbon systems on which experimentally determined phase equilibrium relationships have not yet been reported in the literature. Of course, if reliable experimental data on the phase relationship for the system in question are available, these should be used in such calculuations. If, however, no reliable data are available, it appears that a reasonably accurate prediction of the phase relationship for hydrocarbons which have two or more carbon atoms per molecule can be obtained by the method and correlation given herein.

The accuracy of the correlation has been checked against experimentally determined phase equilibrium constants for ethylene, ethane, propylene, propane, isobutane, n-pentane, benzene, n-heptane, toluene, n-octane, and n-decane. With the exception of n-decane the predicted equilibrium relationships for all hydrocarbons investigated are in reasonably good agreement with experimental data reported in the literature by several investigators.

The following discussion takes up first, previous correlations and methods for prediction of phase equilibrium constants of the hydrocarbons. Then the development of the proposed correlation and method for predicting phase equilibrium constants is described. Following this, a comparison is presented of predicted and observed values on 11 different hydrocarbons, which include olefinic, paraffinic and aromatic types.

Previous Correlations

The first correlations of the fugacity of hydrocarbon vapors with reduced temperature and reduced pressure were presented by two contemporary groups of research workers, namely, Lewis and Luke,[10] and Selheimer, Souders, Smith and Brown.[19] Later, Lewis and Luke[11] corrected and extended their original correlation. The ranges of reduced pressure and reduced temperatuure covered by these early correlations were limited because the data available at that time were not abundant.

Lewis and Kay[9] presented a correlation of fugacity coefficient for hydrocarbon vapors for values of reduced pressure of 0 to 3.0. Newton[14] extended the correlation to values of reduced pressure up to 100 and values of reduced temperature up to 35 but did not confine his correlation to hydrocarbons.

In all of the correlations, however, the range of reduced temperature below 1.0 was covered largely by extrapolation. The correlation of Lewis and Kay extended to reduced temperatures as low as 0.75. It ranged in reduced pressure from 0 to 3.0. Their data at reduce temperatures below 1.0 apparently extened to a reduced pressure of only about 0.8. The correlation for reduced temperatures below 1.0 was extrapolated to a reduced pressure of 3.0. Data at reduced temperatures below 1.0 were rather meager at that time. In this range the fugacity coefficient below the value of about 0.7 must be obtained from equilibrium data on two-phase binary

NOMENCLATURE

		Units
f	= Fugacity (empirical)	Psi.
K	= Phase Equilibrium Constant	—
P	= Pressure (absolute)	Psi.
P_r	= P/P_c = Reduced Pressure	—
R	= Gas Constant = 10.7 when pressure temperature and volume are expressed in units as noted.	
T	= Absolute Temperature	°Rankine
T_r	= T/T_c = Reduced Temperature	—
v	= Molal Volume of Component in Liquid Phase	ft.³
x	= Mol Fraction of Component in Liquid Phase	—
y	= Mol Fraction of Component in Vapor Phase	

Subscripts:

- c refers to critical.
- e refers to pressure of saturated vapor of pure component at temperature in question.
- L refers to liquid phase.
- obs refers to experimentally observed values.
- r reduced condition; absolute pressure divided by absolute critical pressure, absolute temperature divided by absolute critical temperature, or volume/mol divided by volume/mol at the critical point.
- v refers to vapor phase.

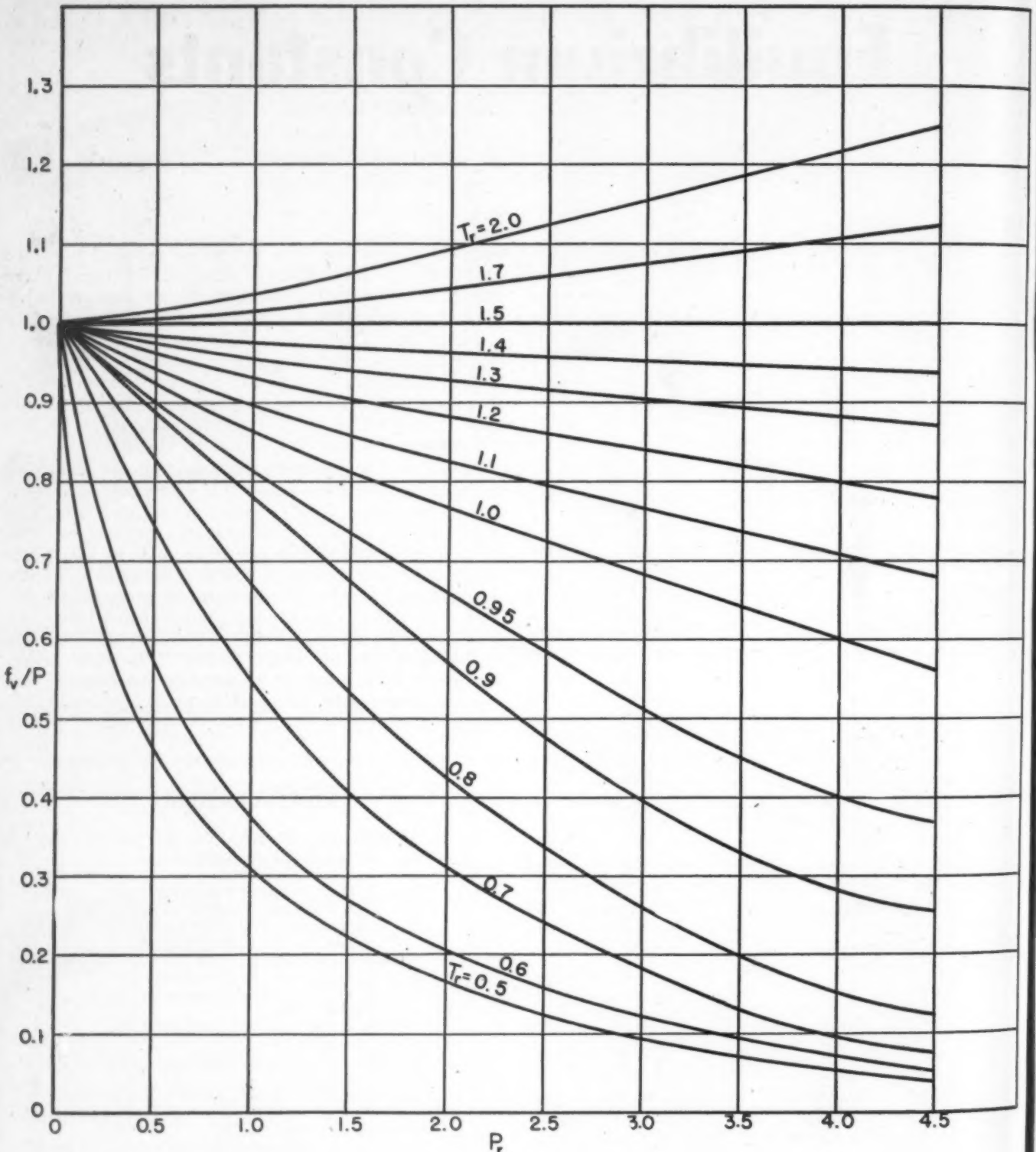

FIGURE 1
Correlation of fugacity coefficient for hydrocarbon vapor.

TABLE 1

Comparison of Observed Equilibrium Constants with Values Calculated By Previous Correlations

Component	Temp. °F.	Pressure p.s.i.	EQUILIBRIUM CONSTANT, K Calc.	Obs.	Percent Deviation	Reference
Ethane	40	100	3.0	3.5	− 14.3	6
Ethane	40	500	0.88	0.92	− 4.3	17
Ethane	40	1000	0.72	0.64	+ 12.5	17
Ethane	40	2000	0.92	0.65	+ 41.6	17
Ethane	120	100	6.90	5.95	+ 16.0	6
Ethane	120	500	1.60	1.45	+ 10.3	17
Ethane	120	1000	1.03	0.97	+ 6.2	17
Ethane	120	2000	0.80	0.77	+ 3.9	17
Ethane	200	100	10.6	10.3	+ 2.9	6
Ethane	200	500	2.37	2.60	+ 8.8	17
Ethane	200	1000	1.36	1.50	+ 9.3	17
Ethane	200	2000	0.91	1.00	+ 9.0	17
Ethylene	40	464	1.25	1.225	+ 2.0	13
Ethylene	40	664	1.00	0.996	+ 0.4	13
Ethylene	60	614	1.20	1.175	+ 0.2	13
Ethylene	60	764	1.05	1.00	+ 5.0	13
Propane	40	100	0.80	0.83	− 3.6	6
Propane	40	500	0.269	0.245	+ 20.8	17
Propane	40	1000	0.345	0.205	+ 68.2	17
Propane	40	2000	0.627	0.33	+ 90.0	17
Propane	120	100	2.08	2.25	− 7.5	6
Propane	120	500	0.66	0.58	+ 13.8	17
Propane	120	1000	0.64	0.42	+ 52.4	17
Propane	120	2000	1.71	0.44	+288	17
Propane	200	100	3.75	4.4	− 14.8	6
Propane	200	500	0.997	1.12	− 11.0	17
Propane	200	1000	0.765	0.73	+ 4.8	17
Propane	200	2000	0.655	0.60	+ 9.2	17
Propylene	165	200	1.90	1.77	+ 7.3	4
Propylene	165	400	1.12	1.06	+ 5.6	4
Propylene	203	300	1.75	1.61	+ 8.7	4
Propylene	203	400	1.40	1.31	+ 6.4	4
Propylene	203	600	1.10	1.03	+ 6.8	4
Isobutane	100	100	0.59	0.738	− 20.1	15
Isobutane	100	500	0.30	0.252	+ 19.1	15
Isobutane	100	1000	0.40	0.249	+ 60.6	15
Isobutane	160	200	0.87	0.853	+ 2.0	15
Isobutane	160	500	0.53	0.493	+ 7.5	15
n Pentane	220	150	0.70	0.680	+ 2.9	18
n Pentane	220	600	0.397	0.284	+ 39.8	18
n Pentane	220	1000	0.49	0.270	+ 81.5	18
n Pentane	280	200	1.00	0.946	+ 5.7	18
n Pentane	280	800	0.63	0.467	+ 34.9	18
n Heptane	300	100	0.578	0.58	− 0.34	7
n Heptane	300	400	0.29	0.235	+ 23.4	7
n Octane	360	145	0.478	0.481	− 6.2	9
n Octane	360	180	0.419	0.360	+ 16.4	9
n Octane	538	290	0.998	1.00	− 0.2	9
n Octane	538	362	0.893	0.896	− 0.3	9
n Decane	400	100	0.381	0.34	+ 12.0	16
n Decane	400	400	0.234	0.114	+105	16
n Decane	400	800	0.510	0.085	+500	16

or muluticomponent systems. Condensation interferes with direct measuurement of fugacity coefficient of single component systems at reduced pressures above what corresponds to saturated vapor.

Sherwood[20] presented the correlation of Lewis and Kay for fugacity coefficient of hydrocarbon vapor as well as a correlation which was developed by W. C. Kay for fugacity of hydrocarbons in the liquid phase below reduced temperature of unity. On the basis of the correlation of Lewis and Kay and the correlation for fugacity of hydrocarbon liquids by Luke,[12] which is similar to the one by W. C. Kay, phase

TABLE 2

Critical Properties of Hydrocarbons[1]

Component	Critical Temperature, °F.	Critical Pressure p.s.i.a.	Critical Volume Cu. Ft./lb. mol.
Paraffins:			
Methane	−116	673	1.58
Ethane	90	712	2.19
Propane	206	617	3.03
n Butane	306	550	4.07
Isobutane	273	544	3.98
n Pentane	387	485	4.97
i Pentane	370	484	4.92
n Hexane	455	438	5.87
n Heptane	512	397	6.82
n Octane	565	364	7.85
n Nonane	613	335	8.83
n Decane	655	312	9.9
Olefins:			
Ethylene	50	748	2.04
Propylene	198	661	2.89
Aromatics:			
Benzene	551	704	4.10
Toluene	609	611	5.05

TABLE 3

Comparison of Observed Phase Equilibrium Constants with Values Calculated by Proposed Method

Component	Temp. °F.	Pressure p.s.i.a.	Calc.	Obs.	Percent Error	Reference
Ethane	40	100	3.29	3.50	− 6.00	6
Ethane	40	500	0.823	0.92	− 10.55	17
Ethane	40	1000	0.560	0.64	− 12.5	17
Ethane	40	2000	0.545	0.65	− 16.2	17
Ethane	40	3000	0.83	0.84	− 1.19	17
Ethane	120	100	6.2	6.9	− 10.1	6
Ethane	120	500	1.50	1.60	− 6.25	17
Ethane	120	1000	0.96	1.03	− 6.8	17
Ethane	120	2000	0.785	0.80	− 1.88	17
Ethane	120	3000	0.84	0.85	− 1.18	17
Ethane	200	100	9.60	10.3	− 6.80	6
Ethane	200	500	2.22	2.60	− 14.7	17
Ethane	200	1000	1.32	1.50	− 13.3	17
Ethane	200	2000	0.935	1.00	− 6.5	17
Ethane	200	3000	0.895	0.94	− 4.8	17
Ethylene	40	464	1.29	1.225	+ 5.3	13
Ethylene	40	664	0.995	0.996	0.0	13
Ethylene	60	614	1.20	1.175	+ 2.13	13
Ethylene	60	764	1.04	1.00	+ 4.00	13
Propane	40	100	0.80	0.83	− 3.6	6
Propane	40	500	0.247	0.245	− 1.63	17
Propane	40	1000	0.214	0.205	+ 4.4	17
Propane	40	2000	0.298	0.33	− 9.7	17
Propane	40	2750	0.522	0.54	− 3.3	17
Propane	120	100	2.36	2.25	+ 4.9	6
Propane	120	500	0.587	0.58	+ 1.21	17
Propane	120	1000	0.442	0.42	+ 5.25	17
Propane	120	2000	0.51	0.45	+ 13.4	17
Propane	120	2750	0.67	0.58	+ 15.5	17
Propane	200	100	4.54	4.40	+ 3.18	6
Propane	200	500	1.14	1.12	+ 1.79	17
Propane	200	1000	0.74	0.73	+ 1.37	17
Propane	200	2000	0.625	0.60	+ 4.17	17
Propane	200	2750	0.72	0.65	+ 10.8	17
Propylene	165	200	2.04	1.77	+ 15.3	4
Propylene	165	400	1.15	1.06	+ 8.5	4
Propylene	203	300	1.65	1.61	+ 2.5	4
Propylene	203	400	1.38	1.31	+ 5.35	4
Propylene	203	600	1.00	1.31	− 2.90	4
Isobutane	100	100	0.76	0.738	+ 2.98	15
Isobutane	100	500	0.242	0.252	− 3.97	15
Isobutane	100	1000	0.218	0.249	− 12.4	15
Isobutane	160	200	0.827	0.853	− 3.14	15
Isobutane	160	500	0.436	0.493	− 11.6	15
n Pentane	100	100	0.186	0.188	− 1.07	18
n Pentane	100	500	0.074	0.070	+ 5.7	18
n Pentane	100	1000	0.0792	0.0765	+ 3.53	18
n Pentane	100	2000	0.179	0.189	− 5.3	18
n Pentane	220	150	0.677	0.680	− 0.44	18
n Pentane	220	600	0.287	0.284	+ 1.06	18
n Pentane	220	1000	0.280	0.27	+ 4.07	18
n Pentane	220	2000	0.560	0.594	− 5.7	18
n Pentane	280	200	1.004	0.946	+ 6.1	18
n Pentane	280	800	0.430	0.467	− 7.9	18
Benzene	248	21.9	1.97	1.88	+ 4.8	5
Benzene	248	36.1	1.20	1.21	− 0.83	5
Benzene	392	131	1.52	1.44	+ 5.55	5
Benzene	392	188	1.11	1.09	+ 1.83	5
Benzene	536	411	1.40	1.255	+ 11.5	5
Benzene	536	560	1.09	1.065	+ 2.35	5
Toluene	248	21.9	0.87	0.883	− 1.47	5
Toluene	248	36.1	0.54	0.553	− 2.35	5
Toluene	392	131	0.855	0.92	− 7.05	5
Toluene	392	188	0.633	0.69	− 8.25	5
Toluene	536	411	0.925	0.948	− 2.43	5
Toluene	536	560	0.744	0.815	− 8.7	5
n Heptane	70	100	0.0108	0.0115	− 6.5	7
n Heptane	70	200	0.0072	0.0070	+ 3.4	7
n Heptane	120	100	0.036	0.035	+ 2.9	7
n Heptane	120	400	0.0195	0.0216	− 9.7	7
n Heptane	300	100	0.558	0.550	− 3.8	7
n Heptane	300	400	0.218	0.235	− 7.3	7
n Octane	360	145	0.439	0.481	− 8.7	9
n Octane	360	180	0.371	0.360	+ 3.05	9
n Octane	538	290	1.00	1.00	0.00	9
n Octane	538	362	0.865	0.896	− 3.46	9
n Decane	100	100	0.00139	0.00106	+ 31.1	16
n Decane	100	400	0.0090	0.0064	+ 40.6	16
n Decane	100	1250	0.0028	0.00125	+124	16
n Decane	400	100	0.354	0.340	+ 4.1	16
n Decane	400	400	0.158	0.114	+ 38.6	16
n Decane	400	800	0.172	0.085	+102.5	16

equilibrium constants were calculated for a number of paraffin and olefin hydrocarbons. The calculations were based on the following relationship:

$$f_L x = f_v y \quad (1)$$

$$y/x = f_L/f_v = K \quad (2)$$

where

f_L = Fugacity of pure component in liquid phase at pressure and temperature of the system.

f_v = Fugacity of pure component in vapor phase at temperature and pressure of the system.

x = Mol concentration of component in liquid phase.

y = Mol concentration of component in vapor phase.

K = Phase equilibrium constant for component at temperature and pressure of system.

Actually the phase equilibrium constants were calculated on the basis of $f_L = f_e$ where f_e is the fugac-

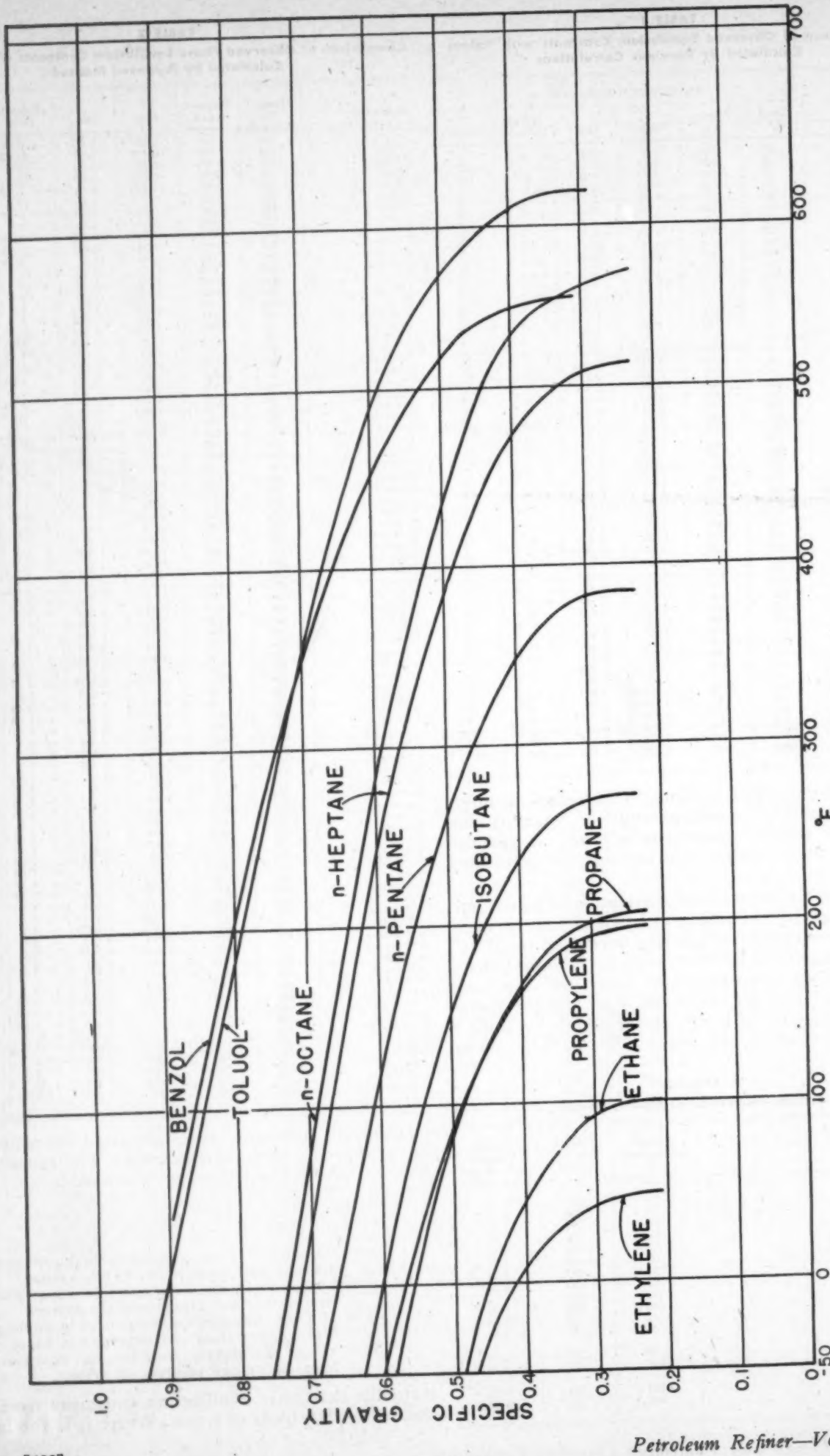

FIGURE 2
Variation of specific gravity of liquid hydrocarbons with temperature.

ity of the pure component in the liquid phase at its vapor pressure which corresponds to the temperature of the system. Thus, the calculations did not include a correction to fugacity of the liquid for the difference between vapor pressure of the pure component and the pressure on the system. Below 500 Psi. pressure this correction can be neglected without serious error. The effect of pressure on fugacity of a component in the liquid phase at constant temperature is shown by equation (3).[19]

$$RT\ln f_L/f_s = \int_{P_s}^{P} v\,dP \qquad (3)$$

where
v = Molal volume of component in liquid phase.
P_s = Vapor pressure of pure liquid at temperature of system, T.
R = Gas constant (10.7) when v is in cu. ft., P in lbs./sq. in. and T in°R)
T = Absolute temperature

Since the variation of v with respect to pressure is usually quite small, equation (3) may be integrated to give equation (4).

$$\ln f_L/f_s = v\,(P - P_s)/RT \qquad (4)$$

Under conditions frequently encountered, the effect of pressure on fugacity of a component in the liquid phase may be substantial.

Table 1 presents a comparison between observed values of phase equilibrium constants and values calculated by the correlations given by Sherwood. It will be noted that for ethylene, ethane, and propylene the calculated results are in general reasonably good. For the other compounds the agreement at low pressure is reasonably good but at pressures above about 500 Psi. the deviation of calculated from observed values is appreciable.

Development of Proposed Correlation

In view of the lack of agreement at pressures above about 500 Psi. between observed and calculated results as obtained by the method just described, it seemed that a correlation could be developed on the basis of experimental results now available on two-phase binary systems which should give better agreement. Also, it seemed that with the data now available the correlation could be extended to reduced temperatures as low as 0.5 over a range of reduced pressure from 0 to 4.5.

After a survey of the phase equilibrium data available the data of Roland, Smith and Kaveler,[17] and of Katz and Hachmuth[6] on methane, ethane and propane, the data by Sage, Reamer, Olds and Lacey[18] on n-pentane and the data by Kay[7] on n-heptane were selected as the basis for the correlation. Those data within 50° F. of the calculated critical temperature of the system were not used in the correlation.

Since the phase equilibrium constant concept is inconsistent with the Phase Rule, it appears that in order for such a correlation to be generally applicable the physical and chemical properties of other components in question must be considered. Gamson and Watson have proposed a basis for such a correlation but unfortunately the data available at this time do not permit development of their proposal. In most cases the phase equilibrium constants reported in the literature were obtained by cross correlation of data on systems of various compositions. Such data do not provide the necessary information to establish the effect of composition of the system on phase equilibrium constants of the individual components of the system.

Initially effort was directed in this investigation toward the development of a correlation on the basis that fugacity of a component in the liquid phase is not affected by pressure due to other components. This, of course, would be the simplest and most convenient correlation to applly because it would eliminate the necessity of applying equation (4). The resulting correlation was not so good as one which included correction for pressure in accordance with

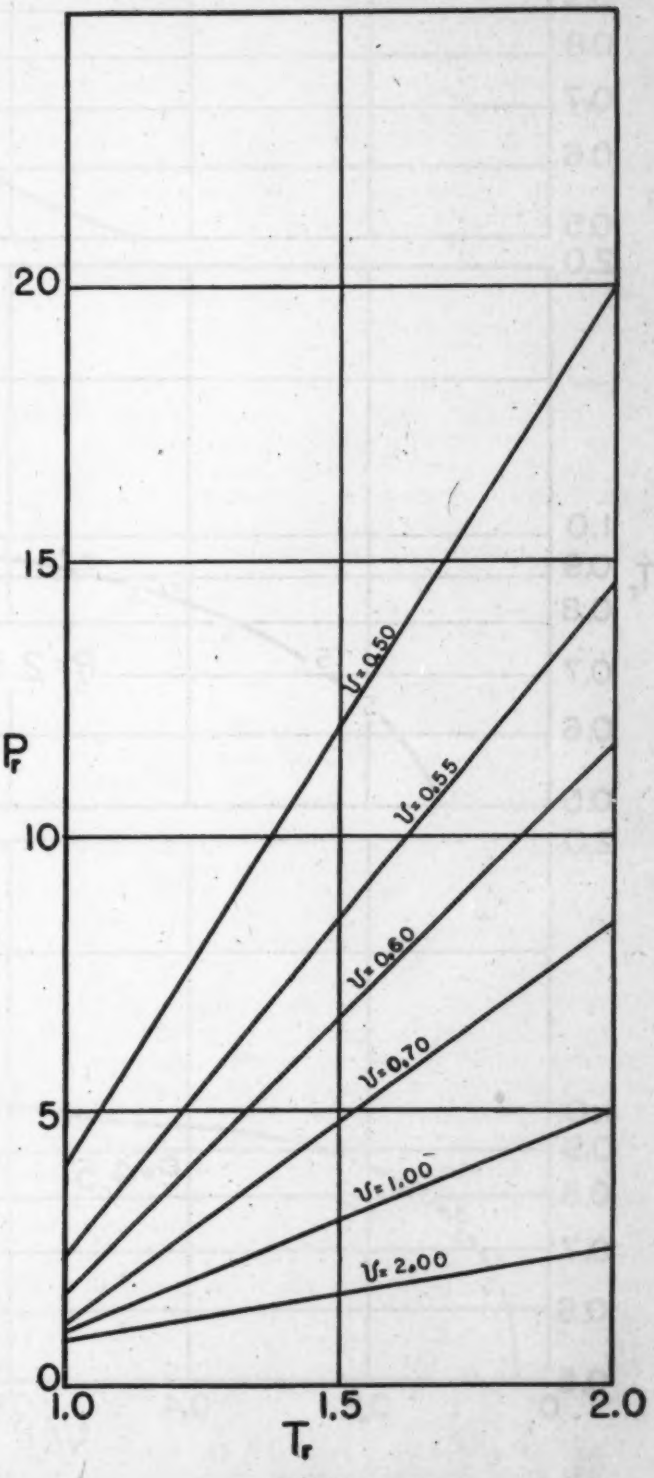

FIGURE 3
Correlation to obtain molal volume of a component in liquid phase above its critical temperature.

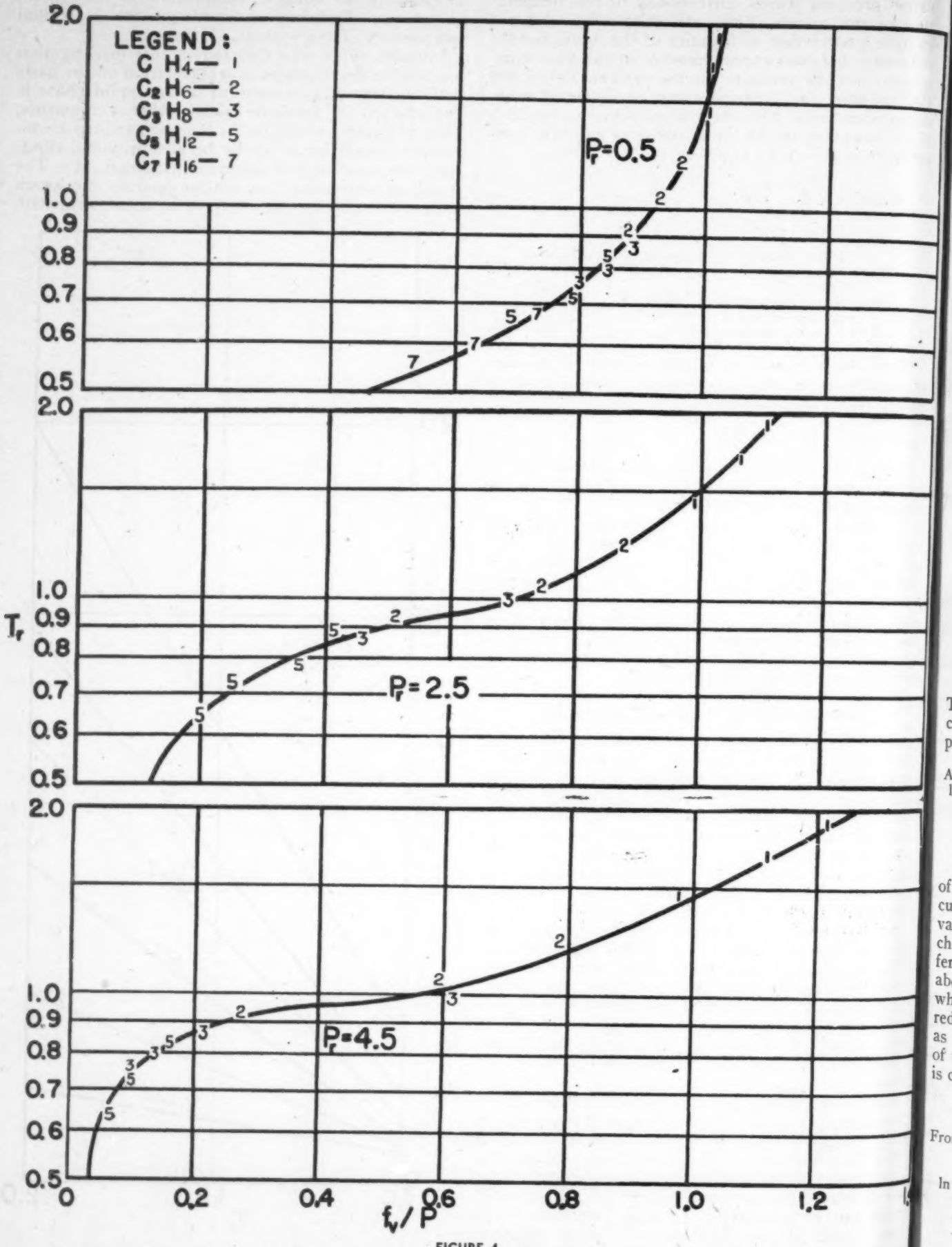

FIGURE 4
Cross-correlation of fugacity coefficient with reduced temperature.

equation (4). This was particularly true at pressures above 500 Psi. Consequently the proposed correlation as presented in Figure 1 requires that the fugacity of a component in the liquid phase, f_L, be obtained by use of equation (4). The fugacity of the component in the liquid phase at the vapor pressure of the pure component, f_e, can be obtained directly from Figure 1 because at this pressure the fugacity of the liquid phase is equal to the fugacity of the vapor phase or $f_e = f_v$ of the pure component at its vapor pressure and the corresponding temperature on the vapor pressure curve. It should be emphasized here that the fugacity as obtained from Figure 1 is empirical because true fugacity is dependent only upon P-V-T relationships. Figure 1 should therefore be used only for calculation of phase equilibrium relations.

The method of correlation involved first the selection of data at a given temperature at which the pressure was varied over a wide range. Calculations were then made at low pressure to determine the value of f_e which would be used throughout the remaining calculations at that temperature for the component in question. For example, consider the correlation of data on ethane at 40° F.

At 10 Psi., $K_{obs} = 34.0$ (Katz and Hachmuth—natural gas and crude oil system)
$P_e = 380$ Psi.; $v = 1.19$ cu. ft. (From Figure 2)
$P_e = 712$ Psi.; $T_c = 550°$ R (Table 2)
$T_r = 500/550 = 0.91$
$P_r = 10/712 = 0.014$; thus, f_v/P is essentially unity (Figure 1)
and $f_v = 10.0$
Since $K = f_L/f_v$
$f_L = 340$ Psi.
From equation (4):
$\ln f_e/f_L = 1.19(380\text{-}10)/(10.7)(500) = 0.082$
$f_e/f_L = 1.085$
$f_e = (1.085)(340) = 370$ Psi.

The value of f_e for ethane at 40° F. was thus calculated to be 370 Psi. Now the value of f_v/P at other pressures and 40° F. can be calculated.

At 1000 Psi., $K_{obs} = 0.64$ (Roland et al)
$\ln f_L/f_e = 1.19(1000\text{-}380)/(10.7)(500) = 0.1373$
$f_L = (1.147)(f_e) = (1.147)(370) = 424$ Psi.
$f_v = 424/K = 424/0.64 = 663$ Psi.
$f_v/P = 0.663$; $P_r = 1.405$; $T_r = 0.91$

For temperatures above the critical temperature of the component in question its vapor pressure curve was extrapolated on a Cox chart to obtain values of P_e. In such cases the value of f_e was always checked by use of observed values of K at two different pressures. The value of v at temperatures above the critical point was obtained from Figure 3 which is a graphical presentation of van der Waals' reduced equation of state. The value of v was taken as that which corresponds to P_e and the temperature of the system. For example, f_e for ethane at 200° F. is calcuulated as follows:

At 10 Psi., $K = 110$ (Katz and Hachmuth)
$P_e = 1680$ Psi.; $P_e/P_c = 2.36$; $T_r = 1.2$
From Figure 3, $v_r = 0.75$; $v_c = 2.19$; $v = (2.19)(0.75) = 1.65$
$P_r = 0.014$; $f_v/P = 1.0$ (Figure 1); $f_v = 10.0$
$f_L = f_vK = 1100$
$\ln f_e/f_L = 1.65(1680\text{-}10)/(10.7)(660) = 0.389$
$f_e = (1.475)\ f_L = 1620$ Psi.
At 100 lbs./sq. in., $K = 11.0$ (Katz and Hachmuth)
At $P_e/P_c = 0.014$; $f_v/P = 0.985$ (Figure 1); $f_v = 98.5$
$f_L = (11.0)(98.5) = 1083$
$\ln f_e/f_L = 1.65(1680\text{-}100)/(10.7)(660) = 0.369$
$f_e = 1.445\ f_L = (1.445)(1083) = 1565$
Use f_e of 1600 Psi.

It is likely that some correction for variation in pressure from P_e should be applied to values of v which are obtained from Figure 3 and applied in equation (4). Even so, it is believed that such a correction would not have a large effect on the final results and can be disregarded without appreciable error in calcuuated values of K or f_v/P. Gamson and Watson[3] presented a method for estimating the molal volume, v, of a component in the liquid phase at a temperature above the critical temperature of the component. Their method is somewhat more complicated than the one used to develop the correlation in Figure 1 and did not appear to be of sufficiently greater accuracy to justify its use in this instance.

After values of f_v/P were calculated from the data on each component used in the correlation, smooth curves of f_v/P as a function of P_r at constant T_r were drawn. Then a cross-correlation of f_v/P as a function of T_r was carried out at several values of P_r. A smooth curve was drawn through the points for each value of P_r as shown in Figure 4 for the specific cases of $P_r = 0.5$, 2.5 and 4.5. Such curves were established at intervals of 0.5 between values of 0 and 4.5 for P_r. These curves were then used to construct the chart of f_v/P versus P_r for constant values of T_r as given in Figure 1.

The correlation of Figure 1 was then checked against reported values of phase equilibrium constants for ethylene, ethane, propylene, propane, isobutane, n-pentane, benzene, toluene, n-heptane, n-octane and n-decane. A comparison of calculated values of phase equilibrium constants with the observed values as reported in the literature is presented in Table 3. The method of calcuuation which utilizes the correlation of Figure 1 is described by the following example on the calculation of the phase equilibrium constant of propane at 200° F. and 2750 Psia. pressure.

$P_c = 617$; $P_r = 2750/617 = 4.45$
$T_c = 666°$ R; $T_r = (200 + 460)/666 = 0.99$
$P_e = 600$; $v = 2.35$
From Figure 1 at $P_r = 4.45$ and $T_r = 0.99$,
$f_v/P = 0.530$; $f_v = (0.530)(2750) = 1460$
$P_e/P_c = 600/617 = 0.97$; From Figure 1 at $T_r = 0.99$,
$f_eP_e = 0.86$; $f_e = (600)(0.86) = 516$
$\ln f_L/f_e = 2.35(2750\text{-}600)/(10.7)(660) = 0.714$
$f_L = 2.04\ f_e = (2.04)(516) = 1050$
$f_L/f_v = 0.72$; this compares with an observed value for K of 0.65.

It will be noted by reference to Table 1 that the results calculated, by the method presented herein, are in somewhat better agreement with observed values than in Table 1. This is particularly true at pressures over 500 Psi. The correlation of Figure 1 permits calculations to be made at reduced temperatures as low as 0.5 compared with a minimum value of reduced temperature of 0.75 in the correlation of Lewis and Kay.[9]

The agreement between calculated and observed values of phase equilibrium constants for n-decane is quite poor although the method presented herein gives somewhat better results than noted in Table 1. There is no sound explanation for the poor agreement between calcuuated and observed values for n-decane. It appears that the fugacity in the liquid phase is somewhat less than would be predicted on the basis of reduced equations of state. With the exception of n-decane, however, the calculated and observed results are in reasonably good agreement.

All of the predicted phase equilibrium constants with this exception are well within 20 percent deviation from observed values. Thus, it appears that in general the method can be used to predict values of phase equilibrium constants within ± 20 percent. It has been found[8] to be convenient for extrapolation of observed values to conditions at which observed values are not available. This is done by calculating a value for f_e based on the observed values of phase equilibrium constants. Then extrapolation to higher pressures is carried out by use of this value of f_e in the method as described.

The extrapolation of observed values of phase equilibrium constants to a different temperature is done by calculating the value of f_e at two different temperature levels at which observed phase equilibrium constants are available. Then a straight line is drawn through these points on a Cox chart. The value of f_e at the desired temperature is obtained by extrapolation of the straight line to this temperature. Values of f_e calculated by this method usually check closely with values obtained by direct calculation from Figure 1 based on the value of T_r at the desired temperature.

Conclusion

The proposed method for prediction of phase equilibrium constants seems to give results more nearly in agreement with observed values than any method published heretofore. This is particuularly true at pressures over 500 Psi. The method is not applicable, however, at temperatures which are within 50° F. of the critical temperature of the system. A generally applicable method has not been published as yet. Any such method should take into account the size and chemical characteristics of the molecules of other components in the system in addition to the one in question. The proposed method is convenient for extrapolation of reliable observed values of phase equilibrium constants to conditions at which observed values are not available.

Acknowledgement

The author is indebted to Robert York for his suggestions and criticisms.

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Safe Practice in Oxy-Acetylene Welding

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Sparks from cutting operation may travel considerable distance.

MANUFACTURERS of oxy-acetylene welding equipment always have endeavored to build every possible safety device into its apparatus and to promote its safe and effective use, but all accidents cannot be prevented by design and construction alone, as facts and records will show.

During the period 1930 to 1940, at least 50 people met death as a result of welding accidents. Twelve lives were lost to the welding of "empty" tanks. Sixteen other people were killed in acetylene explosions. Besides this loss of life, property damage resulting from welding accidents was tremendous. In three years, welding and cutting operations caused 7000 fires. During 1943, fire losses resulting from welding operations amounted to $13,000,000.

Perhaps the most spectacular fire resulting from this cause was the loss of the French liner Normandie on February 9, 1942. Here a $53,000,000 ship was almost destroyed and more than $5,000,000 spent in righting the capsized vessel. One man lost his life in the fire and 258 others were injured.

The amazing fact arising from this catastrophe is, that after the original fire, and in spite of the knowledge that unsafe welding practices caused the mishap, at least two other fires were started on the ship by exactly the same unsafe practices. On March 13, a fire broke out on D deck during welding, but was finally extinguished. On April 18, a more serious fire started when a welding torch ignited cork insulation lining refrigeration compartments. Three alarms were sounded and 16 hours of fire fighting required to halt the flames.

This article, therefore, is intended to accumuluate from the most reliable sources, such as the experience of safety engineers, welding foremen, construction engineers and experienced operators, the safe practices most generally accepted for the oxy-acetylene operation of cutting and welding. These practices are not to be confused with state, municipal, insurance and other laws and regulations. Furthermore, they will be more generally found in oil- and gas-field operations and are intended to apply primarily to that industry although the practices may well apply to all operations involving welding.

Welding and cutting operators should be physically and mentally qualified for the work they are to do. They should be fully instructed on the work and the proper precautions for the job.

It is important that all welders be adequately trained and only permitted to undertake important work when they have passed qualification tests such as those set up by the American Welding Society.

Equipment

Only standard apparatus that has been examined and tested and found to be safe should be used. Material listed and approved by Underwriters Laboratories and Factory Mutual Laboratories is accepted by most authorities.

Cylinders must be constructed and maintained according to regulations of the Interstate Commerce Commission.

Portable Generators

Acetylene should never be generated or used at a pressure in excess of 15 pounds as it may become unstable.

Portable generators are designed primarily for outdoor use and should never be used indoors unless the ventilation is complete or the volume of the room at least 35 times the generator capacity.

Portable generators must be protected against freezing and no salt or other corrosive chemicals is permissible as protection against freezing.

When charged, the generator should not be moved by crane or derrick. If mounted on a movable carrier it should be chained or fastened to prevent overturning.

Each generator should be attended by a trained operator.

Generator should be kept 10 feet or more from flammable material.

Carbide in quantities under 600 pounds, properly

packaged, may be stored inside buildings if the place is dry, waterproof, and well ventilated.

Drums should be handled in rotation as received. Punctured or ruptured drums should be used immediately.

When opening carbide cans, tools that may strike a spark should be avoided.

Open flames, lanterns, and smoking must be prohibited in carbide-storage areas.

Oxygen and Acetylene Cylinders

Most of the gas used in oil- and gas-field welding is purchased in cylinders and these cylinders should be handled with care.

Stored cylinders should be kept away from all sources of heat and in upright position. The acetylene should be separated from the oxygen by some distance unless fire-resisting walls are between them.

Cylinders, if stored in the open, should have valves and safety devices protected against snow and ice.

Never use slings or electric magnets to handle cylinders and be sure that all cyliners have valve protecting caps in place. Avoid sliding or dragging cylinders. Never drop or throw cylinders against one another. They are easily moved by tilting and rolling on their bottom edge.

Valve-protection caps are to protect valves from damage. Do not use pry bars under the valve or cap to loosen cyliners frozen to the ground.

When cylinder holders are mounted on a truck, a partition of asbestos or non-combustible material should be installed and the cylinder securely fastened in an upright position.

Empty cylinders should be plainly marked and kept separate from full cylinders. Be sure all valves are closed.

Because of their weight and shape, cylinders are difficult to carry by hand. Numerous carrying devices are available to make this an easy task. No less than two men should attempt to transport a cylinder by hand.

In using acetylene, the drum should be upright. If there is a leak at the stem when the valve is opened, close the valve and tighten the gland nut. If this does not stop the leak, discontinue use at once, remove the cylinder outdoors with a warning tag attached and notify the supplier. Acetylene leaks can be detected by odor and the location determined by soapy water on fittings. Never test for leaks with open flame.

If a leak develops at a fuse plug or other safety device, take the cylinder to an isolated spot outdoors well away from fire source and slightly open the valve, allowing acetylene to escape slowly. Erect warning signs and notify the supplier.

Never tamper with fuse plugs. Be sure to open cylinder valve slowly and never open the valve more than 1½ turns of the handle.

Always use the special wrench provided for acetylene drums and leave it in position on the stem so that the acetylene may be shut off quickly in an emergency.

Oxygen cylinders and fittings must be kept away from oil and grease as oxygen and oil may ignite violently if united under pressure.

Oxygen cannot be used as a substitute for compressed air. A serious accident may result if it is used to dust clothes, drive pneumatic tools or blow out pipe.

Never use a hammer or wrench to open oxygen-cylinder valves. If the valve cannot be opened by hand, it is in bad order and the supplier should be notified.

Always call gases by their proper name. Say oxygen and acetylene—not gas or air.

Keep all cylinders away from actual welding so that sparks, slag, or flame cannot reach them. Never use cylinders as work benches for rests while welding.

Regulators

Regulators should only be used for the gas for which they are intended. Copper fittings and parts cannot be used on acetylene.

Do not attempt to repair regulators, as such repairs should only be performed by skilled mechanics. Gauges attached to regulators should be tested frequently for accuracy. Do not test the gauges with oil.

Before connecting an acetylene regulator, the cylinder valve may be cracked slightly to blow out grit and dust, but be sure no other welding, flame, or spark is near. Make sure the connection is tight and use proper size wrench. Do not try to force connections which do not fit. Always observe that the pressure-adjusting screw is released by turning to the left before opening the cylinder valve. Open the valve slowly and stand to one side of the face of the gauges. Acetylene cylinders usually have a capacity of 100 to 300 cubic feet of gas under a pressure of 250 pounds.

Before connecting an oxygen regulator, be sure no oil or grease is on the hands, gloves, or equipment. The valve may be cracked to blow out dirt and grit before installing the regulator. Be sure connections are tight and use proper size wrench. Remember that the pressure adjusting screw must be turned counterclockwise until it is loose before opening the cylinder valve. Do not open the valve suddenly as the rush of high pressure oxygen may rupture the regulator. Oxygen cylinders, when full, are under a pressure of 1800 to 2400 pounds.

Never attempt to tighten connections between the regulators and cylinders without first closing the cylinder valve.

If a regulator shows a creep indicated by pressure build-up when the torch is cut off, close cylinder valve immediately and have regulator replaced or repaired.

If regulators are taken out of service for several weeks, it is good practice to turn the pressure-regulating screw just enough to relieve the pressure on the valve seat. This protects the valve and seat.

Regulators are delicate instruments and must not be dropped or handled roughly. Abuse causes their failure.

Hose and Connections

The hose for gas outlets should be of good quality to withstand the service. Separate hose for oxygen and acetylene are safer than the double passage hose. When the two hoses are taped together to prevent tangling, not more than four inches out of each eight should be covered with tape. Metal-clad hose is not desirable.

Red is the accepted color for the acetylene hose and green for the oxygen hose.

Generally, the hose should stand a test pressure of 400 pounds; although for light work, a hose capable of holding 200 pounds pressure for 5 minutes is acceptable.

Hose connections should be marked for identification.

Long lengths of hose should be avoided. They are

more exposed to damage and involve greater waste of gas. One hundred feet is usually the maximum in oil- and gas-field work.

Protect the hose at all times from flying sparks, hot slag, as well as grease, oil, and chemcials.

Avoid kinking the hose or dragging it over sharp or rough objects.

Hose should be neatly coiled and stored in cool, dry locations when not in use. If laid on greasy floors or shelves, it is likely to absorb such material.

New hose is dusted with fine talc which must be blown out before using the hose. Use air for this operation.

All hose should be examined at least once each week for leaks, worn places, loose connections, etc. It can be tested by immersing in water while under normal operating pressure.

Leaks must be repaired at once not only because they waste gas but because they are a source of danger.

If in constant use, it is good practice at monthly intervals to cut off about two inches on each end of the hose and reclamp.

Never attempt to repair hose with tape.

In case of flash-back, the entire length of huse must be discarded. The inner wall has been burned and the hose is unsafe.

Welder following safe practice

Torches

Only torches listed as standard by proper authorities should be used.

Always be sure the torch is properly connected and free from leaks before lighting. Select the proper welding tip or cutting nozzle before starting the work.

The procedure in lighting torches depends upon the design and type of torch used. Always be sure there is oxygen and acetylene in the proper hoses. Follow the manufacturers directions for lighting the torch. Do not use matches. A friction lighter or pilot flame may be used. Be sure that the torch tip is pointed so that burns will not result when the gas ignites.

Never attempt to light a torch in a bell-hole, cavity or furnace where gas may be accumulated.

When work is to be halted for a few minutes, it is permissible to close the torch valves only, but if work is to be stopped for a longer period, the oxygen and acetylene cylinder valves also should be closed.

Unlighted torches should not be left in confined spaces during lunch hour or overnight. The equipment should be taken down, making certain that all valves and screws are in proper closed position.

Back-fire or pre-ignition into the torch tip may be caused by improper handling of the torch such as touching the tip against the work, overheating the tip, operating at improper pressures or loose tip or head.

Flash-back or sustained burning back of the flame into and beyond the mixing chamber is more serious. Causes may be dirty or damaged seating surfaces, cracked or distorted torch head or loose tip and nozzle. In order to prevent flash-backs, the delivery pressure of the gases must be correct and all seating surfaces clean and tight. If a new nozzle, welding head or tip does not remedy the condition, then the seating surfaces are at fault.

When gas pressures become so low that proper delivery cannot be maintained, work must be stopped at once and the gas-supply valves shut off.

A good welder never permits other workmen to play with his torch. He never uses the torch head as a pry bar, hammer or punch. He does not use oversize tips, nozzles, or high oxygen pressure.

Personal Protection

Although there is very little ultra-violet ray in oxy-acetylene welding, the workers' eyes must be protected from flying metal, heat and glare.

Properly designed and colored lenses fitted into suitable goggles should be worn during all welding operations. Helpers or persons in exposed positions also should be provided with goggles.

The selection of the proper goggles should not be left to the worker or foreman. Responsible persons skilled in the protection of the eye should be consulted. The expensive filter lenses should be protected by cover glasses which can be replaced when pitted with slag.

Goggle frames must be non-inflammable, a non-conductor of heat and easily sterilized. Frames should

have vent holes to permit ventilation without side glare.

The following shades of filter lenses are acceptable:

Shade 5 for light cutting and welding.

Shade 6 and 7 for heavy cutting and welding.

Shade 8 for heavy welding.

Lens suitable for acetylene welding should not be used for electric welding.

Woolen clothing is safer than cotton. If aprons are used, they should be of the fire-resistive type. Most oil-field welders prefer the fire-proof gauntlet glove, although the asbestos short glove is acceptable if tight-fitting sleeves are worn.

Shirt collars should be kept buttoned at all times and it is better that pockets be eliminated from jacket or overall fronts. High-top safety shoes are preferred.

Welding in a bell-hole from a prone position exposes the ear and neck. Usually an asbestos glove or cover cloth is thrown across the exposed portion. Screen cup guards are very useful.

Clothing can be flame-proofed by dipping in a solution of ¾ pound sodium stannate in one gallon of water, then wrung out and dipped in a solution of ¼ pound ammonium sulphate per gallon of water. After thoroughly drying, this clothing will stand five or more dry-cleanings before losing its fire-proof quality. Do not wash or boil in water.

Welding or cutting on material resting on oxygen bottles is an unsafe practice.

Fire Protection

Fire is the most serious hazard connected with welding and cutting operations. The first rule is to never use a torch where an open flame would be dangerous. Remember flying sparks and slag may travel some distance. If the work can be moved, take it to a safe place. If cutting is to be done, the distance should be 40 feet or more from any inflammable material.

Keep wood floors clean and wet down before welding. Remember sparks and slag may travel some distance and ignite flammable material. Covers or metal sheets should be laid where hot metal is likely to fall.

Beware of dry grass, leaves and brush on pipe line rights of way. Clean out the welding area or cover with wet earth.

No line should be welded on that has not been shut off, blanked with blind plates, and certified as safe. Lock all gate valves entering the line being worked on.

Never weld on drums, tanks or vessels that have not been checked for inflammable vapors. An explosion meter instrument will detect explosive gases. Although a vessel has been aired, steamed and water washed, explosive vapors may remain.

If possible, drums or vessels should be water filled to within a few inches of the welding point.

Never put down a torch unless the oxygen and acetylene valves have been shut off.

Do not hang torches from the regulator or wind excess hose around the cylinders.

Always carry chemical fire extinguishers as a regular part of the welding equipment.

Welders should always unsnap friction lighters when entering suspicious areas as a bump may cause a spark to ignite any inflammable vapors present.

Be sure and wet down or cover with damp earth all hot slag, trimmings, or cuttings left at the work scene.

When possible, leave cylinders outside of tanks, vessels, or buildings when work is being done.

Do not lay small work on a concrete floor to weld. When heated the concrete may explode with possible injury to the operator.

Health Hazards

A room where welding or cutting is regularly performed must be well ventilated. Strong drafts, however, should be avoided. Permanent or portable exhaust systems are preferred.

When lead is encountered in welding operations, care must be taken that the operator does not breathe the fumes.

When cutting or welding zinc, brass, bronze or galvanized metal, the fumes may cause chills if breathed over a period of time.

Fluxes used in welding usually produce a toxic or irritating fume.

These operations should be performed out of doors, but in all cases care must be taken and air-line respirators worn if conditions are abnormal.

Even in tanks, vessels or pipe, certain oils, sludges, and residue give off harmful vapors when heated and adequate ventilation is important. Tests for oxygen deficiency should be made in all suspicious cases.

General

All safeguards cannot be built into aparatus and much depends upon the individual learning the hazards of the operation and practicing safety at all times.

Acetylene is an anaesthetic, not a poison. Oxygen is a supporter of life, but concentrations in air can cause material to burn more rapidly. The art of welding involves common sense as well as complete knowledge of the work. It is a safe, valuable and time-saving asset to all industry and it is justly proud of its part in our great war record. Its future is unlimited and the practice of safety will eliminate the useless waste of life and property.

REFERENCES

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[2] "Handbook of Fire Protection," by Crosby-Fiske-Forster, National Fire Protection Association, Boston, Mass.

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Small-Scale Fluid-Type Catalytic Unit Designed

N. K. ANDERSON and M. J. STERBA, Universal Oil Products Company

As a result of the experience gained through design and operation of numerous fluid-catalytic-cracking units built during the war for the production of aviation gasoline, Universal Oil Products Company has been able to develop an efficient and simplified catalytic-cracking unit to meet the smaller refiners' needs.

The many improvements and simplifications embodied in the MS-type design have resulted in a marked reduction in investment cost, as well as substantial decreases in operating, maintenance, and utility requirements, so that this unit can now be installed and operated at a cost comparable with that of a thermal-cracking unit of the same capacity. There has been no sacrifice in performance to realize these economies; in fact, there has been an actual improvement in processing efficiency. At the same time, the unit has retained all of the inherent advantages of the original fluid-type operation which make it extremely flexible in regard to conditions at which it can be operated, or charging stocks which can be processed. All of the improvements incorporated in this new MS-type design have been fully demonstrated in pilot plants, semi-commercial scale, or commercially operating units.

As an illustration of the flexibility of the fluid process it can be pointed out that commercial fluid cracking units have been operated with reactor temperatures ranging from as low as 800° F. to as high as 1000° F. Stocks processed commercially have ranged from gasolines to topped crude fed directly to the catalyst section without pre-flashing. Various recycling operations and combinations of catalytic- and thermal-cracking operations have been thoroughly investigated.

The inherent flexibility of the fluid-catalytic-cracking unit plus the economies of the MS-type design combine to make this unit entirely practical for the smaller refiner who is faced with the problem of increasing the octane rating of his motor gasoline.

Flow Diagram

Briefly, the flow shown by Figure 1 for the new MS-type unit is as follows:

The oil feed is charged as a liquid at the base of the reactor riser; hot catalyst from the regenerator enters this riser at the point of oil injection, supplies the process heat requirements, and is transported upward by the vaporized oil into the reactor.

Spent catalyst is continually withdrawn from the upper part of the reactor dense phase to hold the level in the reactor and is passed downward through the stripping section into the regenerator. Inert gas prepared by water-scrubbing a small portion of the flue gas is used for stripping.

Catalyst flows downward through the regenerator counter-current to the air supplied at the bottom for combustion. Additional stripping of the spent catalyst is obtained in the upper section of the regenerator where the bulk of the flue gas from the combustion of coke in the lower sections contacts the incoming catalyst.

Regenerated catalyst flows from the lower section of the regenerator into the reactor riser at a rate controlled to maintain a constant reactor temperature. The regeneraotr-flue gas is vented to the atmosphere through an internally mounted cyclone separator which recovers entrained catalyst and returns it to the regenerator dense phase.

The reaction products pass into the fractionator vapor line through an internally mounted cyclone separator which recovers entrained catalyst and returns it to the reactor dense phase. The vapors enter a conventional fractionating column where column bottoms, a side-cut stream, gasoline, and gas are prepared in the customary manner. Heat is recovered by circulating column bottoms through a steam generator and returning the oil stream to the fractionator at an intermediate point. Adequate facilities for stabilizing the gasoline and preparing polymerization feed have been provided.

Discussion

The experience gained by Universal Oil Products Company through the operation of numerous fluid-catalytic-cracking plants has been applied to the design of the new MS-type unit. This new development permits substantial reductions in installation costs as well as lower operating costs with improved performance. The major modifications in the MS-type unit as compared with the fluid unit of earlier design which have made these benefits possible are:

1. The regenerator and reactor have been combined into a single vessel which is erected as a self-supported column and is completely shop fabricated for moderate-size units. In all sizes the heavy structure required in the earlier units has been eliminated.
2. The large regenerator riser has been eliminated; the regenerator standpipe is greatly shortened; and there has been a general elimination and simplification of small piping.
3. All equipment for secondary catalyst recovery, such as a Cottrell precipitator or an oil scrubber on the regenerating side, and a slurry settler or slurry recirculating system on the processing side, has been eliminated.
4. The efficiency of both the reactor and regene-

rator has been improved by the use of additional distribution grids in each section.

5. The air supplied for combustion passes through the regenerator countercurrent to the flow of catalyst.

The obvious simplification of the unit as indicated by the changes listed in the first three points results in a marked reduction in total investment, in maintenance charges, and in operating costs. This saving in itself is a major item. Then, paralleling this simplification process, there has been a redesign of the remaining elements of the plant to make them function with the greatest possible efficiency. Here the experience gained through operation of fluid catalyst plants has dictated the following changes:

1. Unlined pipe is used throughout the unit.

2. The countercurrent regenerator results in only air passing through the main distribution grid. The distribution is simple and positive.

3. The system of catalyst flow control has been modified to reduce erosion on the control valves. Experience in the field indicates that these changes have eliminated this difficulty.

4. The design of the cyclone separators used in the new unit is such that maintenance is a minor item.

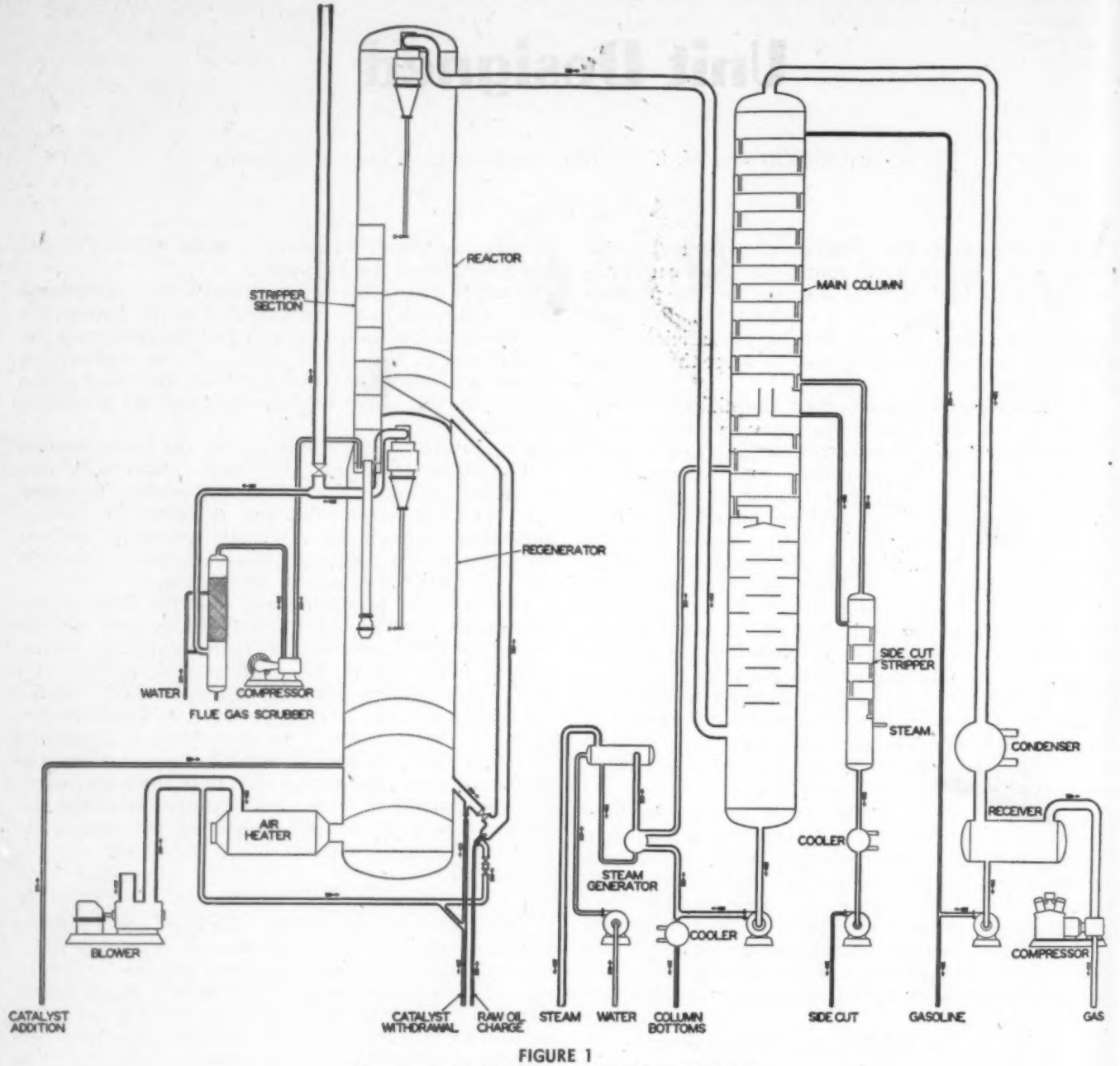

FIGURE 1

Flow diagram, UOP MS-Type catalytic cracking unit.

5. A monolithic regenerator lining of refractory cement has replaced the former brick lining.

All of the simplifications and mechanical changes noted above result in investment, maintenance, and operating economies which are of fundamental importance in adapting the fluid-catalyst plant to the smaller refiners' needs.

Improvements in Efficiency

It has long been felt that more effective use could be made of the catalyst in the reactor both in regard to conversion and product distribution. It has been found that the installation of additional grids achieves both purposes: first, it permits running at higher

space velocities for a given conversion; second, it improves the product distribution by giving more gasoline and less gas and coke at a given conversion. Both effects are quite appreciable. The grids function to prevent circulation of catalyst and reaction products (principally gasoline) from the top of the reactor dense phase toward the bottom. The circulated reaction products acted to decrease the effective oil partial pressure and hence, decreased conversion; at the same time, recirculated gasoline was cracked further to gas and coke, resulting in a loss of yield. The installation of additional grids has markedly improved the processing efficiency of the reactor.

The stripper has been completely redesigned and several installations indicate considerable improvement resulting from the changes. It has been so arranged in the reactor that flow of spent catalyst from the reactor dense phase into the stripper can occur only at the top of the reactor dense phase while the level is allowed to vary. This gives a true top drawoff of spent catalyst from the reactor and obviates by-passing of regenerated catalyst and unconverted raw oil into the stripper. This same feature enhances the effect of the additional grids in the reactor.

To improve the primary function of the stripper, i.e., to remove oil vapor from the spent catalyst going to the regenerator, the geometric proportions have been changed to give a stripper with a high length-to-diameter ratio; in addition, the stripper has been staged by adding grids. Both mechanical changes result in a marked improvement in stripping of spent catalyst by reducing "end-over-end" mixing.

With the countercurrent flow of catalyst and air through the staged regenerator it has become possible to improve its efficiency. The countercurrent flow makes feasible complete oxygen utilization with the additional feature of another period of hydrocarbon distillation and stripping of the spent catalyst in the upper section of the regenerator where the bulk of the flue gas from the combustion of coke in the lower sections comes in contact with the incoming catalyst. These points, together with the redesign of the reactor which improves the product distribution, permit a substantial reduction in regeneration requirements, both in vessel size and in air quantity.

The more favorable carbon-oxygen relationship in this staged regenerator results in an increased carbon-burning rate despite the considerably lower average temperature of the dense phase. In addition,

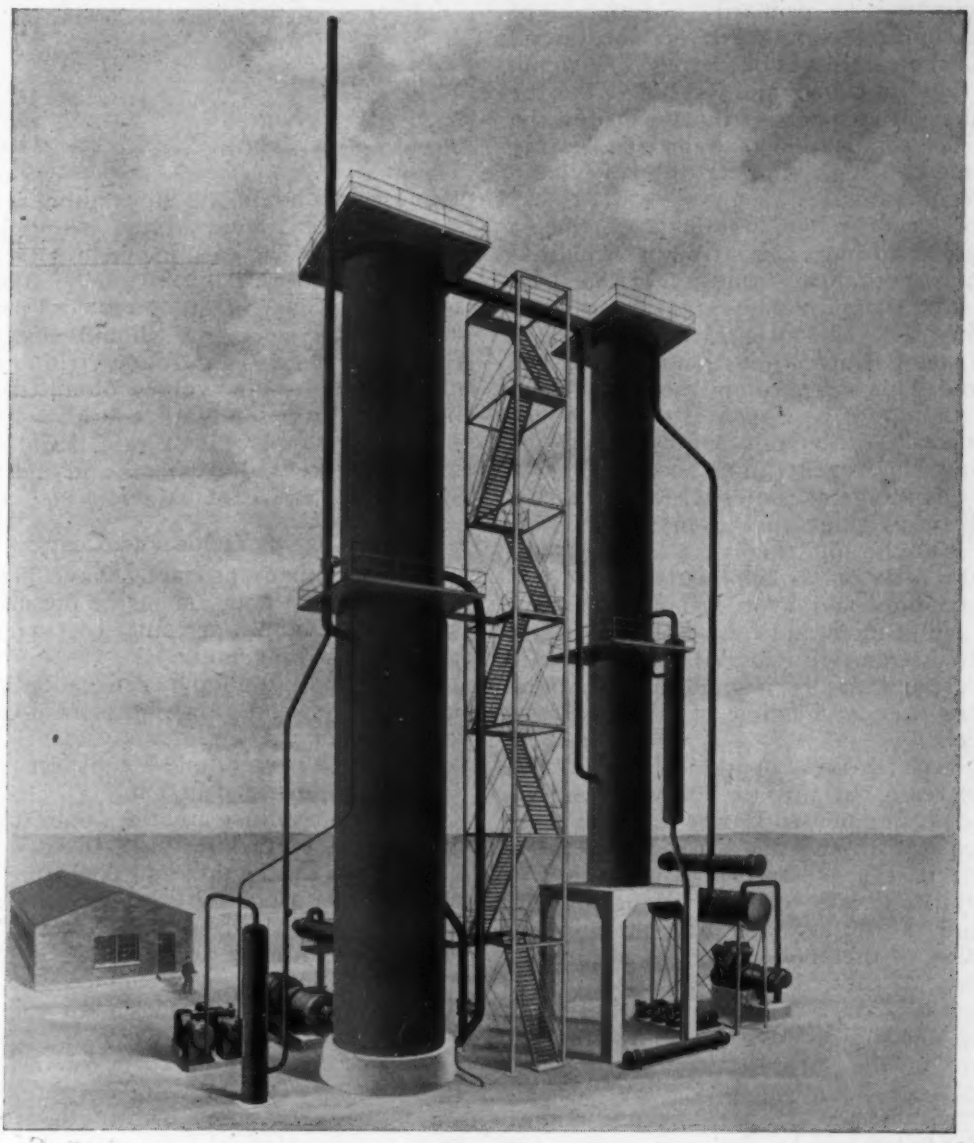

FIGURE 2
UOP Type MS small-scale catalytic cracking unit

the regenerator is designed to run under pressure which further increases the carbon-burning rate.

Catalyst Activity

This increase in burning rate, at a given temperature, effected by staging the regenerator with countercurrent operation at a higher pressure, permits an appreciable reduction in the volume of catalyst required in the combustion zone. This point is directly related to the question of catalyst consumption in the cracking process. Hence, at this time the general case of catalyst deactivation and mechanical losses will be considered.

Catalyst deactivation is primarily a function of high temperature plus steam, when no substantial contamination of the catalyst is occurring. The steam can be either that adsorbed and occluded by the catalyst in the present strippers or that formed in the regenerator by the combustion of hydrogen-bearing catalyst deposits; the high-temperature zone is in all cases the regenerator.

The source of steam in the first instance can be eliminated by going to inert-gas stripping. This has been done, with a simultaneous redesign of the stripper to permit low stripping-gas rates in order to avoid overloading the gas-concentration equipment.

In the case of steam from combustion the effect can only be minimized. This was accomplished first by improving the stripping of the spent catalyst which reduces preferentially the amount of hydrogen-rich material entering the regenerator. Second, it was done by taking advantage of the countercurrent flow of catalyst and air to stage the regenerator. There are three stages; at the top, there is a low-temperature section with little or no combustion, acting as an additional stripping and hydrocarbon-distillation zone; next, a zone of moderate temperature wherein the remaining hydrogen-rich material is burned with the least ill effect; and, finally, a small high-temperature zone where the combustion of low-hydrogen coke takes place.

The above-given features of the MS-type unit substantially decrease the rate of catalyst deactivation. Their effect is augmented by the lower average regenerator temperature and the decrease in volume of catalyst held in that vessel resulting from the higher carbon-burning rate realized by the installation of grids and the higher operating pressure.

After evaluation of the above-indicated reductions in the rate of loss of catalyst activity, the emphasis on the question of catalyst consumption becomes one of reducing mechanical losses. In view of this, the development of the MS-type catalyst assumes particular importance. This type of catalyst is made in the form of microspheres, extremely resistant to attrition, small enough to be fluidized easily, and large enough to make recovery by a cyclone separator very simple. Furthermore, the abrasion of metal parts is considerably less by the MS-type catalyst when compared to ground powder. Performance tests have verified the desirable properties of the microspherical form and all evidence points to a well balanced catalyst which will minimize the rate of replacement.

Catalysts

The most simple design of the MS-type unit is based on the use of the microspherical synthetic catalyst (MS catalyst). However, a catalyst in the powdered form, either synthetic or natural, can be used with certain additions to the basic plant design. Two synthetic MS-type catalysts, silica-alumina and silica-magnesia, are available. Silica-alumnia catalyst would be used if maximum octane rating is the primary consideration. The gasoline yield with silica-magnesia catalyst is substantially higher but the octane rating is lower. Because of the lower cost per pound of the natural catalyst its use should also be considered. This catalyst gives a gasoline yield and octane rating intermediate to the values obtained with the synthetic catalysts but with a higher coke production and catalyst replacement rate. Economic considerations of market requirements and operating costs will govern the choice of catalyst.

TABLE 1

Typical Yields and Product Qualities

U O P MS-Type Catalytic Cracking Processing Mid-Continent Gasoil Once-Through Operation at 65 Percent Conversion

CATALYST	Silica-Magnesia	Natural	Silica-Alumina
Yields, Volume Percent:			
Debutanized 400° F. E P Gasoline	53.0	48.9	45.5
Cycle Stock, 400° F	35.0	35.0	35.0
Butylenes	5.5	5.8	6.2
Butanes	5.5	7.4	10.9
Propylene	3.8	4.8	6.8
Propane	1.9	3.4	3.7
C_2 & Lighter Gas, Weight Percent	1.9	1.7	1.7
Debutanized 400° F. E P Gasoline (5-6 Lb. R. V. P.)			
Octane No. ASTM (F-2)			
Clear	79.1	80.3	82.1
+3 cc. TEL	85.2	86.5	87.7
Octane No. Research (F-1)			
Clear	89.0	90.8	93.0
+3 cc. TEL	95.4	96.5	98.7
Cycle Stock, 400° F. +			
Gravity, °API	26	26	26
C_3 and Lighter Gas			
Molecular Weight	12	12	14
Heating Value, Btu/Cu. Ft.	740	740	840

Yields and Costs

The accompanying tables have been prepared in order to give a comprehensive picture of the yields, productions, and operating costs of the MS-type catalytic cracking unit.

Yields and product qualities obtained in a once-through operation on a typical Mid-Continent gasoil with each of the three catalysts at a constant conversion of 65 percent and a constant reactor temperature are summarized in Table 1.

In order to illustrate the application of the MS-type catalytic cracking unit, there is shown a summary of the production and operating costs for three sizes of operations with each of the three catalysts. This study is based on MS-type units having gasoil charge capacities of 1000, 3000, and 5000 barrels per stream day with an on-stream efficiency of 90 percent.

The production summary with and without subsequent polymerization of the C_3-C_4 olefins appears in Table 2. The operating costs for the catalytic cracking units are given in Table 3. A summary of operating costs for the complementing UOP polymerization units is presented in Table 4.

Operating costs for the catalytic cracking units are based on receiving a gasoil charge stock and cover the entire operation of the unit through adsorption, debutanization of the catalytically cracked gasoline, and preparation of a liquid polymerization feed. The various items of cost together with the corresponding rates used in the estimate are listed separately in Tables 3 and 4. The catalytically cracked gasoline can be finished in almost all cases with no treatment other than a caustic wash and the addition of inhibitor.

Summary

In closing, it should be pointed out that the greatest single advantage of the fluid-type catalytic-cracking unit is its flexibility. Commercial fluid units have been

operated with reactor temperatures ranging from as low as 800° F. to as high as 1000° F. Stocks processed commercially have ranged from gasoline to topped crude fed directly to the catalyst section without preflashing. Various recycling operations and combinations of catalytic and thermal cracking operations have been thoroughly investigated.

The many improvements and simplifications found in the MS-type design have reduced investment and operating costs until they compare favorably with the costs of a thermal cracking unit of the same capacity. This has been accomplished while retaining all of the inherent advantages of the original fluid-type operation and improving its processing efficiency.

The economies and improved performance of the MS-type design with all of the flexibility of the fluid cracking process make this unit entirely feasible for the smaller refiner who is faced with the need of raising the octane rating of his motor gasoline.

TABLE 2

Production Summary for Once Through Catalytic Cracking of Mid-Continent Gasoil

Catalyst Form Type Catalyst	Microspherical Silica-Magnesia			Powdered Natural			Microspherical Silica-Alumina		
Charge, Bbls. per Calendar Day	900	2700	4500	900	2700	4500	900	2700	4500
Conversion, 100—Volume percent Cycle Oil	65	65	65	65	65	65	65	65	65
C_2 and Lighter, MCFCD	164	494	822	147	441	735	126	379	631
C_2 and Lighter, 10^6 Btu/CD	121	363	605	108	375	541	106	319	531
Propylene, BCD	36	108	180	43	129	215	61	183	305
Propane, BCD	17	51	85	31	92	153	34	101	168
Butylenes, BCD	50	150	250	52	156	260	56	168	280
Isobutane, BCD	39	117	195	54	161	268	82	246	410
N-Butane, BCD	10	30	50	13	40	67	16	48	80
Debutanized—400° F. EP Gasoline, BCD	477	1430	2385	440	1320	2200	409	1230	2045
Cycle Oil, BCD	315	945	1575	315	945	1575	315	945	1575
Overall Yields Without Polymerization:									
10-Lb. RVP, 400° F. EP Cat. Crkd. Gasoline, BCD	503	1510	2515	463	1390	2315	431	1291	2155
10-Lb. RVP, 400° F. EP Cat. Crkd. Gasoline, Vol. %	55.9	55.9	55.9	51.5	51.5	51.5	47.9	47.9	47.9
Cat. Crkd. Gasoline F-2 ON Clear	79.8	79.8	79.8	80.9	80.9	80.9	82.4	82.4	82.4
Cat. Crkd. Gasoline F-2 ON + 3 cc. TEL	86.7	86.7	86.7	87.9	87.9	87.9	88.6	88.6	88.6
Excess Butanes, BCD	63	189	315	84	252	420	117	350	583
Cycle Oil, BCD	315	945	1575	315	945	1575	315	945	1575
Fuel Gas, MCFCD	264	790	1317	282	845	1410	300	901	1501
Fuel Gas, 10^6 Btu/CD	368	1103	1840	443	1330	2216	536	1610	2682
Overall Yields with Polymerization:									
10-Lb. RVP, 400° F. EP Cat. Crkd. Gasoline, BCD	503	1510	2515	463	1390	2315	431	1291	2155
10-Lb. RVP, 400° F. EP Cat. Crkd. Gasoline, Vol. %	55.9	55.9	55.9	51.5	51.5	51.5	47.9	47.9	47.9
10-Lb. RVP Motor Polymer, BCD	54	162	270	60	179	299	72	217	362
10-Lb. RVP Motor Polymer, Volume Percent	6.0	6.0	6.0	6.6	6.6	6.6	8.0	8.0	8.0
Total 10-Lb. RVP Gasoline, BCD	557	1672	2785	523	1569	2614	503	1508	2517
Total 10-Lb. RVP Gasoline, Volume Percent	61.9	61.9	61.9	58.1	58.1	58.1	55.9	55.9	55.9
Excess Butanes, BCD	19	57	95	38	113	188	66	197	329
Cycle Oil, BCD	315	945	1575	315	945	1575	315	945	1575
Fuel Gas, MCFCD	224	672	1120	247	742	1237	232	694	1158
Fuel Gas, 10^6 Btu/CD	276	828	1380	363	1089	1814	377	1130	1884
Cat. Crkd. Gasoline F-1 (Research) ON Clear	89.7	89.7	89.7	91.2	91.2	91.2	93.5	93.5	93.5
Cat. Crkd. Gasoline F-1 ON +3 cc. TEL	96.3	96.3	96.3	97.2	97.2	97.2	99.5	99.5	99.5

TABLE 3

Summary of Operating Costs for UOP MS-Type Catalytic Cracking Units

	Microspherical Silica-Magnesia			Powdered Natural			Microspherical Silica-Alumina		
Charge Throughput—BCD	900	2700	4500	900	2700	4500	900	2700	4500
Operating Costs per Calendar Day:									
1. Operating Supervision at $350 per month	$ 11.70	$ 11.70	$ 11.70	$ 11.70	$ 11.70	$ 11.70	$ 11.70	$ 11.70	$ 11.70
2. Operating Labor at $1.20 per hour (average)	86.40	115.20	115.20	86.40	115.20	115.20	86.40	115.20	115.20
3. Maintenance Labor and Materials	66.00	132.00	182.00	73.00	146.00	269.00	66 00	132.00	182.00
4. Utilities	48.70	114.10	164.90	51.70	123.10	176.50	48.70	114.10	164.90
Net Steam at 25¢/M lbs. Circ. Water at 2¢/M gals. Fuel at 15¢/MM-Btu. Electricity at 1¢/KWH.									
5. Laboratory (additional) Labor and Chemicals	48.80	48.80	48.80	48.80	48.80	48.80	48.80	48.80	48.80
6. Catalyst	67.50	202.50	337.50	27.00	81.00	135.00	67.50	202.50	337.50
7. Royalty	45.00	135.00	225.00	45.00	135.00	225.00	45.00	135.00	225.00
8. Taxes and Insurance	22.00	44.00	61.00	25.00	49.00	90.00	22.00	44.00	61.00
Cost per Barrel Charge	$396.10 44.0¢	803.30 29.8¢	1146.10 25.5¢	368.60 41.0¢	709.80 26.3¢	1071.20 23.8¢	396.10 44.0¢	803.30 29.8¢	1146.10 25.5¢

TABLE 4

Summary of Operating Costs for UOP Liquid Feed Catalytic Polymerization Units

(To Complement Catalytic Cracking Operating Costs in Table 3)

	1	2	3	4	5	6	7	8	9
10-Lb. RVP Polymer Produced BCD	54	162	270	60	179	299	72	217	362
Operating Costs per Calendar Day:									
1. Operating Labor at $1.20 per hour (average)	$ 28.80	$ 28.80	$ 28.80	$ 28.80	$ 28.80	$ 28.80	$ 28.80	$ 28.80	$ 28.80
2. Maintenance Labor and Materials	8.00	10.30	15.00	8.00	10.30	15.00	8.00	10.30	15.00
3. Utilities	15.60	40.20	65.40	17.00	44.00	72.10	19.80	52.70	86.70
Steam at 25¢/M lbs. Circ. Water at 2¢/M gals. Fuel at 15¢/MM Btu. Electricity at 1¢/KWH.									
4. Laboratory (additional)	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
5. Catalyst	6.70	20.20	33.60	7.40	22.30	37.20	9.00	27.00	45.10
6. Royalty	10.10	30.20	50.40	11.10	33.40	55.80	13.45	40.50	67.60
7. Chemicals	3.80	11.40	18.90	4.20	12.55	21.00	5.00	15.20	25.40
8. Taxes and Insurance	6.20	8.00	11.70	6.20	8.00	11.70	6.20	8.00	11.70
Cost per Gallon 10-Lb. RVP Polymer Produced	$ 87.20 3.85¢	$157.10 2.31¢	$231.80 2.04¢	$ 90.70 3.60¢	$167.35 2.22¢	$249.60 1.99¢	$ 98.25 3.25¢	$190.50 2.09¢	$288.30 1.90¢

No Peace for Fractionators

P. J. HARRINGTON, B. L. BRAGG III, and C. O. RHYS, JR.
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THE war has increased the amount of engineering research in the petroleum industry to improve the efficiency and capacity of refinery process unit operation equipment, such as fractionating towers, furnaces, heat exchangers, mixers and separators, compressors, and pumps. Examples of how this problem was approached in one company on one type of operation during the war are given. Minor changes in the internal structure of towers of representative prewar design increased atmospheric crude pipe still throughputs from less than 30,000 barrels capacity to 40,000 to 50,000 barrels with excellent separating efficiency while representative light ends fractionators for separating iso- and normal butane were increased in limiting vapor loads from 20,000 to 45,000 barrels at over 100 percent efficiency. Through the Technical Advisory Committee of the Petroleum Industry War Council and through the Petroleum Administration for War, the findings have been made available during the war to assist the industry in its war work. Extension of this type of engineering research is recommended.

This paper was presented before the Division of Refining, American Petroleum Institute, Chicago, November 14, 1945.

AT THE beginning of the war, the petroleum industry of this country had a very large investment in refinery process units. Wartime construction added another sizeable increment. Of the total, it has been estimated that some 25 to 30 percent is in distillation-type equipment. Fractionation continues to be the basic operation in petroleum refining, figuring prominently in a wide variety of processes from crude distillation in shell and atmospheric and vacuum pipe stills through thermal and catalytic cracking steps with associated absorption and light end recovery and separation units, to rerun stills, extractive and azeotropic distillation plants, and solvent extraction facilities. The newer blending agent operations for aviation and motor gasoline components, such as cumene, alkylate, polymer, and isomerization products, are quite dependent on efficient fractionation. Even the growing field of chemical by-products from alcohols to additives, and from resins, plastics, and rubbers to solvents for them, involves this important process.

Long before the first world war, the theory of the separation of two-, three-, and multi-component mixtures by fractionation had been established and a rather complete literature now exists upon the subject. Design engineers in this and other industries had established a basis for producing the equipment to do the job required. This art had, however, reached the stage where only a limited amount of further investigation seemed worth while. It was common practice on multi-component mixture designs, such as those for crude stills where anything approaching super-fractionation was not needed, to work from an empirical formula involving a so-called "critical" vapor velocity when sizing towers. This formula varied somewhat from company to company, but in essence involved the fundamentally sound principles controlling the fall of liquid droplets through rising vapors with one of those constants to tie in lack of proper use of theory with experience known to the initiate as "factors of ignorance". For number-of-plate requirements, experience was (and remains) the best guide. Where depropanizers, debutanizers, etc., were involved, plate-to-plate studies were often made assuming a 90 percent plate efficiency as reasonably close to the 100 percent which would, by definition, appear to be limiting. Even in such cases, a few extra plates were added as experience dictated. By and large, very creditable results were obtained by the design engineers.

Accelerated Tower Design Changes

The advent of the latest war accelerated a change which was already under way in tower design. At the same time that developments in aviation blending agents called for large-scale units capable of true superfractionation, the need for pure chemical compounds, such as toluene, butadiene, isoprene, and isobutane (to mention but a few), became imperative. Lack of time, materials, and manpower were coupled with a demand for increased crude runs to make well-fractionated virgin aviation base stocks and optimum quality gasoils for catalytic cracking. The most urgent new equipment called for extrapolating design formulas for 6- to 10-foot crude towers to 12- to 18-foot sizes. Light-ends fractionators grew to 10- to 12-foot diameters with 50 to as many as 150 plates and reflux ratios involving Niagara-like flows across them. As the war progressed, even these giants were called on for more and more output. Crude runs came up and cracking severity increased as the insatiable Ickes called for more fuel for the war machine.

The response of the industry to this demand is common knowledge and to single out the work of any one group can be justified only as a specific example on which to fasten a plea for continuing wartime engineering research, particularly in the important field of fractionation. For that reason, we have chosen two examples which point the way in the fields of crude and light-ends fractionators.

In the fall of 1941, Standard Oil Company of New Jersey put into operation in its Bayway refinery two single-stage atmospheric crude pipe stills, each designed to reduce 28,000 barrels per stream day of East Texas crude to 20 percent bottoms, or 32,000 barrels per stream day of West Texas crude to 30 percent bottoms, making a variety of well-fractionated products from a light naphtha overhead to a heavy gasoil bottom side stream. The main towers with sections of 12 feet 6 inches and 16 feet 6 inches in diameter represented considerable extrapolation from previous company (and most industry) high-liquid-load towers. The reflux and pump-around rates

for the required fractionation called for flows as high as 115,000 gallons per hour of hot liquid across the plates of these large towers. Gaps of 5 to 25° F. were expected, based on the 95 percent and 5 percent points of adjacent cuts.

Operation Difficulties

In operation, difficulties were encountered with these units at less than design throughput, the fractionation being poor while trouble was encountered in withdrawing the refined-oil side stream for product and a stream for cooling to induce reflux in the tower when returned as pump-around. After some study and attempts to improve operations by changing draw-off pan arrangements, it was concluded that some kind of liquid by-passing was occurring. Plate gasket leakage as a source of trouble was eliminated and "dumping" due to plate liquid inlet side bell-cap flow reversal became suspect.

It was decided to study the hydraulics of the tower plates with air and water, and half of a spare plate was set up on a wooden-box structure where air could be passed up through the section at varied rates while water was allowed to flow across it. An extensive program was carried out by the Technical Service Division of Standard Oil Company of New Jersey and Standard Oil Development Company from which it was possible to develop quantitatively what had happened in the large tower. Valuable data for correcting the troubles encountered and for improving future design were obtained, including moving pictures of normal, abnormal, and corrected flow conditions. The remedies for the trouble were evident once the difficulty was understood. Extremely simple changes were made to the large tower plates and it has since been possible to charge up to 45,000 barrels per stream day of crude to these units, obtaining gaps between 95 percent and 5 percent points ranging from 20° to 35° F. on contiguous cuts. Furnace capacity is a limitation to the present feed rate. These results added in no small measure to Bayway's ability to perform outstandingly in producing war products.

In developments of this sort, it is evident that improvements are only possible as a result of the perfect cooperation of operating and technical people when studies of units pushed to their utmost are involved. In this case, great credit redounds to Mr. E. F. McTernan, Bayway atmospheric distillation department head, for just that sort of cooperation.

Reviewing the water and air studies and much work undertaken since 1941, it is possible to reconstruct the Bayway crude-still tower troubles rather completely. For the sake of brevity, the fitting together of the puzzle will be passed over and the composite outlined.

A first fallacy involved that old bugaboo of dimensional similarity which has so often caught the unwary. A mouse cannot be enlarged proportionately to become an operable elephant. Designs which operate perfectly when they are used for towers 6 feet in diameter may run into trouble when scaled up to 16 feet. It has long been known and for years engineering students have been told that if one attempts to flow liquid across a bubble cap tray, a liquid gradient is set up as is the case in a river and flow may back up and flood the tower. In practice, the student soon learns that in a few feet in a tower one can normally scarcely detect the liquid gradient even at heavy flow rates and that this gradient is negligible, compared to the usual downcomer height, so that the tower in practice does not flood from this cause.

Troubles in Large Towers

On the other hand, novel troubles do develop in large towers at high flow rates, causing great difficulty. With vapor passing up through all of the Bayway crude tower plate bubble caps, if the liquid flow across the plate is small, uniform and satisfactory operation results. As the liquid flow increases, the resistance due to the caps, to the vapor stream, and in the original tower, to the hold-down bars on the bubble-cap rows (transverse to the liquid flow) establish a gradient which may eventually amount to from one to several inches of flowing liquid. In a 16-foot tower, even this may seem small. The average tower, however, has in the past contained as many caps as could conveniently be fitted in to improve vapor distribution and contact and these have been designed for minimum reasonable pressure drop. The drop through such caps may be from one to several inches of flowing liquid equivalent. Now, if the head on the liquid-inlet side of the plate caps, due to an "insignificant" liquid gradient, is greater than that on the liquid-outlet side of the plate caps, and if this differential head is of the same order of magnitude as the small pressure drop through the caps, vapor flow will be reduced and finally stopped through the liquid-inlet side caps as the liquid gradient increases.

Note that overflow weir height, plate spacing, or *average* depth of liquid on the tray, do not, in themselves, affect this maldistribution of vapor flow. The important ratio is that of the plate liquid gradient to the cap pressure drop. At a given vapor loading, as more and more inlet side caps are blanked off by rising gradient as liquid flow increases, pressure drop through the fewer and fewer active vapor-loaded caps increases to tend to stabilize the tower operation. Since vapor loading normally increases with liquid loading (constant feed and product rates with increased heat input increasing vapor loading and reflux rate), a further stop to extreme blanketing usually exists. Despite these brakes, if excessive liquid loading is built up, the head of liquid on the liquid-inlet side plate caps will exceed the average plate cap pressure drop (even though this has increased as blanking takes place) and liquid will spill down through the inet side caps to by-pass the plate and to affect adversely the fractionation. If a liquid sidestream product or pump-around draw-off is located at the outlet of a plate so by-passed, a very limited amount of draw-off is possible.

It should be pointed out that the phenomena outlined differ from "flooding" as usually defined where a tower "pukes' or will not pass the liquid charged to it. A "dumping" tower may give no external evidence of abnormal operation, especially if no large sidestream withdrawals are attempted. Many towers given even tolerably good fractionation by the standards of experience for such towers may be "dumping" and thus losing fractionation.

As will be discussed below, gradients may become so high as to back up liquid to the top of the downcomer and so actually "flood" the tower. This is most likely where plate spacing is too close; overflow weirs too high or weir length too short; or downcomer submerged weirs are too short, too close to the plate, or partly obstructed by first-row caps. Combinations of these troubles may cause flooding or

complications may be introduced by vapor cross-flow, as discussed below. The Bayway crude pipe stills did not "flood", but did "dump" badly.

Causes of Dumping

To discover a cause is to make remedy less difficult. The causes of "dumping" are: (1) too long a liquid path; (2) low cap pressure drop; and (3) excessive resistance to liquid flow across the plate. Multi-pass plates reduce liquid path length but have some other disadvantages such as the possibility of maldistribution between passes. This occurred in one company's three-pass tower. For large towers and high liquid rates, excessive gradients may be set up on each pass. Multi-pass replacement plates are also more expensive than other remedies for most existing towers.

Cap pressure drop may be increased where excess tower pressure is available by lowering average operating pressure or by modifying cap layout or design. The former alternative also improves the relative volatility of the lighter components compared to the heavier, and this is an advantage in improving separation or reducing reflux rate up to the point where true vapor velocity limitations due to spray entrainment from properly balanced plates with uniform vapor distribution are encountered. Condenser conditions may, in other cases, be limiting.

Caps may be replaced by others designed for greater pressure drop, or chokes may be installed in existing chimneys. Blanking certain caps in a properly chosen pattern will be effective as will wider cap spacing in replacement or new plate design. If the cap pattern is identical over the plate, a remedy for the troubles outlined is effected, but if caps are redesigned, blanked, choked, or more widely spaced on the liquid-outlet side of the plate than on the inlet side, a better operation results, as will be discussed below. By using higher chimneys or chimney extensions on the inlset side of the plate, compensation for full rate gradient may be provided. Sloped or stepped plates have also been proposed for this purpose. Such expedients have evident disadvantages (which may not be serious) at low tower throughputs.

Considering liquid flow resistance, cap hold-down bars placed transverse to liquid flow, are the chief offenders. A few ½-inch or even 1½-inch bars may seem insignificant in a scale drawing or on inspection of a 15-foot diameter tower with 3-foot plate spacing, but in terms of liquid-flow path they can have much the same effect as the Notre Dame line would have on an aspiring high school half-back. In passing, it may be noted that hold-down bars paralleling the liquid flow are not favored lest they tend to cause maldistribution of liquids in the plane normal to its flow. While the only partially explored problems associated with this type of liquid channelling will not be detailed herein, it is evident that such channelling can seriously interfere with good fractionation without tower flooding or dumping and should be avoided by careful attention to peripheral cap placement; inlet- and outlet-weir shape, height, location and clearance; and by care in locating charge and product lines.

Cap shape influences resistance somewhat and "streamline" caps have been proposed, but with high flow rates submergence minimizes this resistance for normally rounded caps. Cap pitch must be watched to avoid a pattern of vapor jets which tends to obstruct liquid flow at high vapor rates while promoting localized excessive spray height and poor overall liquid-vapor contact. Another of many resistance-reduction proposals involves specially designed caps with vapor slots so arranged as to blow or pump liquid across the plate, augmenting flow and minimizing gradient by a limited cross "air-lift" or vapor-jet action.

Soon after the Bayway crude pipe stills had achieved the successful operation outlined above, a large atmospheric rerun pipe still which had been under construction while the crude still troubles were being eliminated, came into operation at that refinery. In its initial run, a new phenomenon was encountered which the crude still and air-and-water studies did not explain. At high throughputs a surging action seemed to take place in a regular cyclic manner. A rush of liquid through the downcomers was clearly audible at about two-minute intervals and this period appeared to be as regular, as immutable, and at least sounded as torrential as Old Faithful itself. The sidestream draw-off from the surging plates when opened wide varied through the cycle from a full stream to a trickle.

Observation Ports

To study this new difficulty, recourse was had to glass-paneled ports in the tower through which internal conditions could be observed. These had been discussed in connection with the crude towers, but only became necessary to study rerun-tower surges. Operating management again showed commendable cooperation in permitting installation of these untried devices, which appeared less fool-proof than calculations would have them. However, in operation they were quite successful, not only on low-pressure towers, but subsequently on 100-pound isobutane towers. Consisting of two tempered pyrex glass blanks six inches in diameter with ground gasket surfaces installed in flange-type fittings on manhead covers, one was used as a spotlight port while observations were made through the other. Excellent visibility entirely across the tower and for a considerable part of the space from downcomer to overflow weir was possible. Later scales were installed within the tower to assist in estimating liquid levels and spray heights and subsequently quite satisfactory moving pictures of the multi-pass tower mentioned above were made through such ports by the St. Clair Processing Corporation, of Canada, including photographs of surges in that tower.

The observation ports emphasized a situation which had been hypothecated as a result of the earlier studies but which had not been fully evaluated. The air-and-water installation had one serious shortcoming in that only one plate was used. If a second had been superimposed on the first, as in the case in a tower, with liquid flowing in the opposite direction from that on the lower plate, an occurrence called vapor cross-flow would have been noted in the space between the plates at heavy liquid rates where the liquid gradient forced more than a proportionate share of vapor to rise through the lower plate on the liquid-outlet side. Due to the fact that the liquid-outlet or high-vapor-rate side of the top plate is above the liquid-inlet or low-vapor-rate side of the lower plate, vapor cross-flow occurs from above the liquid-outlet side of the lower plate to below the liquid-outlet side of the upper plate.

That this must occur had been deduced from the air-and-water work and in correcting the crude pipe still plates to stop dumping, an effort had been made to reduce vapor cross-flow tendency simultaneously.

As noted above, if more caps are redesigned, blanked, choked, or more widely spaced on the liquid-outlet side of the plate than on the inlet side, it should be possible by proper choice of cap arrangement to obtain uniform vertical vapor flow from every section of the plate for a certain liquid flow rate and total plate vapor rate. Such an arrangement will lead to vapor cross-flow concurrent to liquid flow over the plate at liquid rates below the balance rate and vapor cross-flow countercurrent to liquid flow will again take place if the liquid rate is raised substantially above the balance rate of the modified plate. Thus, it is possible to fix a plate to operate completely in balance for only one liquid- and vapor-rate combination. This rate is usually chosen near to the anticipated maximum, assuming that some concurrent flow of liquid and vapor across the plates while coming up on the unit or during infrequent low charge rate periods will not be harmful. Perfect balance even at high rates is usually not essential to quite excellent operation.

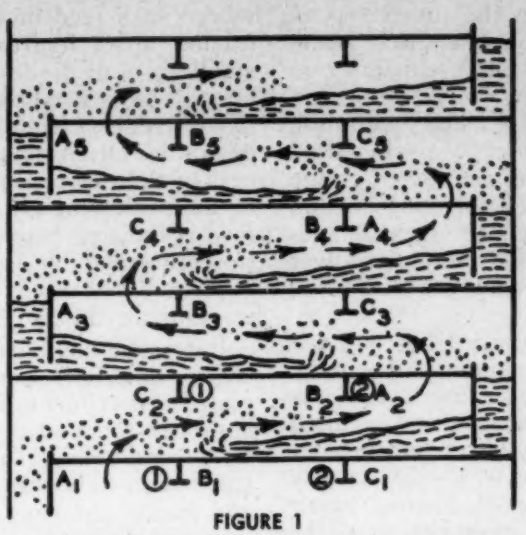

FIGURE 1

Typical countercurrent vapor cross flow. Conditions shown are for countercurrent vapor cross flow typical of plate action on the Bayway rerun pipe still prior to plate revisions; arrows show direction of cross vapor flow.

Vapor Cross Flow

To return to the rerun pipe still case, an apparently reasonably balanced plate design had been inporated in the unit. The observation ports, however, showed that at one point in the surge cycle, a small amount of overall vapor cross-flow existed. Whereas the crudestill tower plates had been supported by beams paralleling the liquid flow across the plates, the heavy cast-iron rerun trays of a different manufacturer's design was supported by two deep "I" beams bisecting the two halves of the plate and running transverse to the liquid flow direction. Droplets of accumulated entrainment falling from those beams were seen to be diverted upstream relative to plate liquid flow by mild countercurrent vapor cross-flow at surging throughputs. The cross-sectional tower area was 133 square feet, but the clearance area between the beams and the liquid surface was only 12 square feet (12- to 14-inch vertical clearance). Across this limited area a small amount of vapor cross-flow carried considerable entrained spray upstream on the plate where it was deposited as vapor cross-flow velocity decreased. This swelled the volume of liquid trying to cross the plate. This, in turn, both increased the gradient to cause more vapor cross-flow and decreased the under-beam clearance to aggravate upstream liquid pile-up. The vicious circle of events was repeated until, after a couple of minutes, pressure drop across the under-beam area became so great as to build up enough pressure beneath the liquid-inlet side of the plate above to discharge over the top plate the dammed-up liquid thereon.

At the same time, the built-up pressure reduced the volume of incoming vapor entering the outlet-liquid side of the lower plate thus forcing the vapor to purge the lower plate. With purging over, normal plate operation preceded another build-up and purge, and so on. Caps were blanked so as to eliminate countercurrent vapor cross-flow and, to some extent, these blanks were so placed as to reduce spray height in the under-beam limiting area. This unit has now operated at above design load without surges or other tower limitations.

The necessarily involved description of surging may be clarified by reference to Figure 1 which illustrates diagrammatically the state of the tower just before the plates are suddenly cleared of accumulated excess liquid. Vapors from A_1 pass through the bottom plate of those shown into space C_2, but due to liquid hold-up in space A_3, they must pass over to A_2 and thence into space C_3 Constriction at the plate support beam section (noted by items [1] and [2]) build up sufficient pressure in spaces C_2 and C_3 to cause vapors to break through from C_2 to A_3 and from C_3 to A_4, thus clearing the plates but setting the stage for another surge as vapor cross-flow reestablishes the liquid holdup in spaces A_2, A_3, A_4, etc.

The lessons learned from the Bayway crude and rerun stills and the air-and-water studies were put to use in the design of new pipe stills for Baltimore and Baton Rouge. Improved plates were designed for these units which were otherwise duplicates of the Bayway units and intended to reduce 30,000 barrels per stream day of Southwest Louisiana or equivalent crude to 16 percent bottoms. It was anticipated that the plate changes incoporated in these units would permit over-design throughputs but since the war program would permit no hold-up in the construction work already under way to reduce the size of the tower and since the refineries could increase their war contribution with excess crude distillation capacity or efficiency, larger charge pumps, more furnace surface, and other limited changes were made to the units while under construction to permit taking advantage of some of the expected excess tower capacity.

Up to Expectations

Both these units have come up to expectations as may be evidenced by a few figures on the Baton Rouge unit. Within four days of first firing, the charge rate was 30,000 barrels per stream day, and the unit has taken 50,000 barrels per stream day of Southwest Louisiana crude to 18 percent bottoms with adjacent cut gaps of from 10° to 15° F. better than design. The furnace limits capacity. Vapor velocities are over 200 percent of the "critical" velocity mentioned previously.

In the course of studies involving greatly increasing alkylate producing capacity in the Jersey Company refineries early in the war, a 10-foot diameter, 50 single-pass-plate isobutane tower was tested. This tower charged some 7500 barrels per stream day of alkylate and butanes, producing 5000 barrels per stream day of 80 percent isobutane-content overhead product, about 1 percent of the butanes left in the bottoms being isobutane. Reflux meters indicated 25,000 to 30,000 barrels per stream day but careful heat and material balances proved that much of the pump-

back was being carried over from the tower top as liquid. Despite this upset condition, the tower operated smoothly and had an overall plate efficiency as usually defined of about 80 percent.

With the crude and rerun still findings in mind, differential pressure drop manometers were installed on each set of five adjacent plates of the tower, gauge glasses were used near the tower top and bottom to indicate liquid levels in the downcomers, and, subsequently, observation ports were placed on the tower at several points. An extended study revealed the following information:

Whereas the crude stills had dumped but had not flooded, the isobutane tower was found to be badly flooded. High liquid-flow rates had caused gradients across the plates which upset vapor flow and resulted in countercurrent vapor cross-flow as outlined above. In this case, however, due partly to a considerable number of transverse plate support beams, vapor cross-flow velocity was so high over much of the plate as to entrain liquid spray upstream. Unlike the rerun still, however, surging did not occur, and the build-up of liquid was only limited by filled downcomers. With 27 inches of plate spacing, there was good evidence that the outlet weirs were submerged about 12 inches while the plate submergence on the liquid inlet side in the tower proper was as great as 25 inches. It is remarkable that smooth operation and fair fractionation resulted under these conditions. When the tower load was reduced to eliminate flooding, a total overhead vapor load (product plus reflux) of only 20,000 barrels per stream day was possible.

The remedies outlined above were applied to the tower plates and, in addition, downcomer to plate clearances were increased, and some caps located too close to overflow weirs removed. It was necessary to make two successive plate modifications but well before the close of the war this tower was able to handle 45,000 barrels per stream day of vapor and liquid load with a plate efficiency of at least 106 percent using the most conservative of careful special duplicate sample analyses. There was good reason to believe the true efficiency was more nearly 145 percent.

In all, six Jersey Company affiliate alkylation unit isobutane towers were modified with a most gratifying effect on alkylate and aviation gasoline output. It should, of course, be noted that seasonal condenser water temperature conditions and other considerations limited application of the findings, and in no case has a tower limitation as such been reached. Reboiler capacity was provided by using 100-pound steam on units designed for either high-pressure or exhaust steam, vapor and liquid lines from the reboiler to the tower being increased in size, Preheat was also increased by using live steam, supplemented by improved techniques to minimize preheater fouling.

Tower-Charge Hydraulics

It may be well at this point to mention the need for consideration of tower-charge hydraulics. Just as an obstruction in any single-plate downcomer must result in flooding the entire tower, so upset hydraulics where charge enters a tower may lead to flooding. Cold feed, or even hot or slightly vaporized feed, particularly in a tower producing a high bottoms-to-charge ratio, may impose an excessive liquid load on the feed and lower plates and flash disturbances where such feed meets hot reflux in the tower may further upset hydraulic balances easily affected by small absolute forces. In some cases, a plate with vapor by-passes to permit introducing feed, mixing it with reflux, and allowing vapor separation may be desirable. Often over-flashing feed by preheat in excess of the theoretical optimum for fractionation may be desirable when liquid load at and below the tower feed is limiting capacity. The small loss in fractionation efficiency due to over-flashing may be more than made up by the increase in reflux possible when minimizing below-the-feed flooding tendency.

Reference has been made to isobutane tower plate efficiencies. It is, perhaps, unfortunate that the generaly used criterion for fractionating efficiency is the approach to point equilibrium. When the work done by a commercial plate equals that which would result from establishing equilibrium between the liquid and vapor entering that plate, it is said to be 100 percent efficient. This expression discourages attempts to exceed a 100 percent figure. Where liquid enters a commercial plate, however, it *successively* contacts a series of vapors of constant or varying composition, depending on the degree of vapor mixing between plates. Lewis* has shown that a plate efficiency, expressed in the usual terminology, of as much as 300 percent may be possible on a commercial plate under certain conditions. Probable overall average plate efficiencies in the isobutane towers discussed have reached 145 percent and higher levels may be possible with improved tower designs. These efficiencies have been based on samples of plate liquid from several points in the tower, while spectrometric analyses and build-up of low concentration components by successive low-temperature fractionations of samples have been used to obtain reliable results.

The information outlined in this paper has been presented in various reports and through oral discussions to the Technical advisory Committee to the Technical Committee of the Petroleum Industry War Council. Companies throughout the industry have thus had the benefits of the findings to assist them in meeting war-fuel requirements. The Petroleum Administration for War has also used the work in their studies of Defense Plant Corporation units. Stimulated by the Development Company data, other companies have also contributed to the widely-known T.A.C. tower study reports.

Standard Oil Development Company plans to continue its fractionating-tower studies, using the most up-to-the-minute results of its work to improve the efficiency and capacity of other existing equipment as has been done in the examples cited. Where bottlenecks other than towers limit units, these may be removed as such, or equipment may be doubled up so as to release towers here and there for new units or duties. Worthwhile economies will be possible in new unit designs when advantage is taken of the lessons learned from such studies as are outlined above. It is hoped that extension of these studies by other companies will increase the ability of the petroleum industry to offer to the nation in peace, as in war, better products at lower costs. Unequivocally, although the war is over, there is "no peace for fractionators," taking the word to apply to pieces of equipment or to those who must design, test, and operate them. Indeed, the whole wide field of process equipment unit design demands engineering research and more engineering research.

* W. K. Lewis, Jr., "Rectification of Binary Mixtures," *Jour. Ind. and Eng. Chemistry*, 28, 399 (1936).

FUNDAMENTALS OF
Consistency and Viscosity

J. J. BIKERMAN

PART 1

In this article the scientific basis of consistency and viscosity tests is discussed. It is shown that, although the relevant laws are fairly simple for some selected systems, many liquids, slurries, pastes, etc., met with in petroleum technology do not comply with the simple laws. Their behavior must be understood and expressed in scientific terms; otherwise an application of laboratory tests to production or an application of production experiences to a new production problem may result in a costly failure. The present article is intended to further this understanding. It will be published in three instalments. In the first, simple systems ("Newtonian liquids" and "perfect solids") are dealt with; the second instalment will bring a review of complicated systems; and in the third consistency and temperature and miscellaneous tests will be reviewed.

I. Introduction

THE ease or otherwise with which petroleum, its derivatives, lubricating greases, etc., move under the action of an external force is nearly always important for their transportation and very often essential for their performance.

The mobility of crude oil determines the speed of its underground movements from one into another stratum and, hence, interests the petroleum geologist.[1] Production of crude oil involves its movement through pipes, and a similar flow takes place on the way of the crude to refineries, etc., as well as on the way which gasoline has to pass from the car tank to the carburetor. The lubricating efficiency of oils and greases depends on their mobility; in many instances the viscosity of the lubricant is its only important property (in addition, of course, to very essential properties not connected with lubrication, as, e.g., absence of corrosive action, a low fire hazard, etc.).

Naturally, this importance has been recognized long ago, and many methods have been devised to test the relevant properties of petroleum products. Not only have many methods been devised, but several of them are still in use, and this simple fact is rather revealing. When the scientific basis of a phenomenon is well understood, it usually does not take much time to work out the best method of its testing, and this best method gradually displaces all the rest. When some well-known physical property has to be measured within a very broad range of conditions, several different instruments may be used for these measurements, but every type has its more or less definite range of application.

Temperature measurement is a case in point. Temperature can be determined by means of a mercury thermometer, or an alcohol thermometer, a thermocouple, an optical pyrometer, etc., but in most cases it is clear what instrument has to be used and why. Whatever instrument is selected, the results of the measurement are expressed in identical units, say, in degrees Centigrade or degrees Fahrenheit.

Testing of consistency does not present an equally happy picture. Even if we restrict ourselves to tests adopted, finally or provisionally, by a single organization, we find a bewildering variety of methods, units and names.

In 1942 Book of A.S.T.M. Standards[2] there are tests for "penetration," for "consistency," and for "viscosity," in addition to tests for "melting point" or "softening point" in which also a kind of consistency is measured. When a needle or a sharp cone is immersed into a paste or a grease, the depth of immersion is a measure of "penetration," but when the immersing body is a rod, instead of the depth the time of immersion is determined and is considered to be a measure of "viscosity." When a petroleum product or a lubricant flows out through a hole under the action of its own weight the time of outflow determines the "viscosity" of the liquid; but when a similar time of outflow is measured for a lacquer the "consistency" of the lacquer is found.

In further sections of this review more will be said on some A.S.T.M. tests for the *rheological* properties of petroleum products (that is properties connected with mechanical deformations of solids and liquids; consistency, viscosity, "body," etc., are rheological properties); here the attention is focused only on the fact of apparent discrepancies within one book, moreover a book published by a highly authoritative society after much deliberation by the best specialists. Of course, not the American Society for Testing Materials is responsible for the imperfections noted above; it is our knowledge of *rheology* which is so imperfect.

In the following sections some fundamental facts of rheology will be reviewed using as much as possible examples taken from petroleum technology. It will be seen that their systematization has not yet progressed far. Both writing and reading of reviews on rheology will be easier when, at some future date, a standard classification of rheological effects will be adopted; in the meantime we must find our way as well as we can.

II. Normal Viscosity

The rheological behavior is relatively clear for two extreme types of substances. One is called *normal*, or *perfect*, or *simple*, or *Newtonian* liquid. The other is a

perfect solid. Very many petroleum products do not belong to either of these types; their behavior is complicated and will be discussed in Sections V to XII. This section is devoted to Newtonian liquids.

Consider a layer of liquid between two plane and parallel walls of which one is stationary and the other moves at a uniform speed (Figure 1). Liquid particles which at a zero time were stretched across

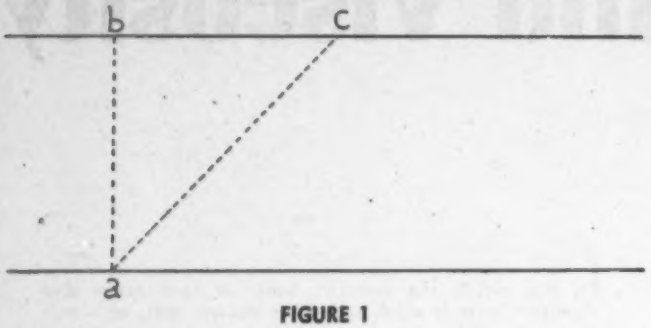

FIGURE 1

the layer along the line ab will at a time t form a line ac. If the liquid has a normal viscosity, this line is straight. The distance between the lines ab and ac, divided by t, is the velocity at a given level. The gradient of this velocity u is for normal liquids constant across the liquid layer; if the distance of a point from the immovable wall is x, then $\frac{du}{dx}$ is independent of x.

Liquids for which ac is a straight line are termed Newtonion liquids because Newton was the first to express the law of their movement:

$$f = \eta \frac{du}{dx} \qquad (1)$$

Here η is viscosity and f is the force acting per square centimeter (or another unit area) of the boundary between two adjacent liquid layers; this force retards the slower and accelerates the more rapid layer. Every thin layer is acted upon by two forces, namely $\eta\left(\frac{du}{dx}\right)_1$ at the boundary 1 between the observed layer and the one next to it which moves more rapidly, and $\eta\left(\frac{du}{dx}\right)_2$ at the boundary 2 between the observed layer and one which is slower than it. If $\left(\frac{du}{dx}\right)_1 = \left(\frac{du}{dx}\right)_2$ and η is constant, the forces $\eta\left(\frac{du}{dx}\right)_1$ and $\eta\left(\frac{du}{dx}\right)_2$ are numerically equal and no resulting force acts on the thin layer. Therefore, it moves without acceleration, i.e., at a constant speed, which is to be expected as the upper plate was assumed to move at a uniform rate. This discussion is quite elementary but is reproduced here to facilitate comparison with a later discussion (Section VI) of non-Newtonian liquids.

Sliding of two parallel plates can be used for determining viscosity of liquids. P. G. Nutting[3] describes an apparatus of this kind. A steel tongue is slowly pulled out of a narrow space between a pair of fixed steel plates; the space is filled with the liquid to be examined and the rate of movement of the tongue is determined for various pulling forces. The instrument (Figure 2) is not suitable for liquids like water or light hydrocarbons the viscosity of which is low and surface tension relatively high, since the tongue may be wetted by the liquid and withdraw a liquid film, thus increasing the surface area of the liquid; in this case the rate of movement is influenced also by capillary forces.

Many instruments use tangential displacement of two coaxial cylinders as this system is mechanically more reliable than one involving a thin steel plate. To this type belong the apparatuses made by Pocchettino,[4] R. N. Traxler and H. E. Schweyer,[5] W. A. Brown,[6] and H. L. D. Pugh.[7] Here the product $\eta\frac{du}{dx}$, x being the distance of a point in the liquid from the axis of the inner cylinder, is not constant since the area of a cylindrical surface is the larger the larger is the radius of the cylinder, but the product of "force per area" times "area," i.e. $\eta\frac{du}{dx} \times x$, is constant in the space between the two cylinders. Because of the complications introduced by surface tension and the difficulties involved in producing extremely narrow and still uniform slits, these instruments as well found application only for very viscous liquids like bitumen or asphalt. See Figure 3.

Instead of displacing two coaxial cylinders along their common axis, one of these cylinders can be rotated about this axis and the torque exerted on the other cylinder measured. This type (Figure 4) is associated with the name of Couette.[8] E. Hatschek,[9] H. Freundlich[10] and many other investigators used similar viscometers. The test for viscosity of insulating varnishes published as D 115-41 by A.S.T.M. specifies a MacMichael viscometer which has many

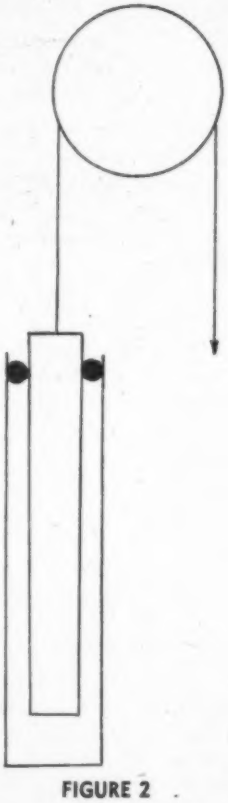

FIGURE 2

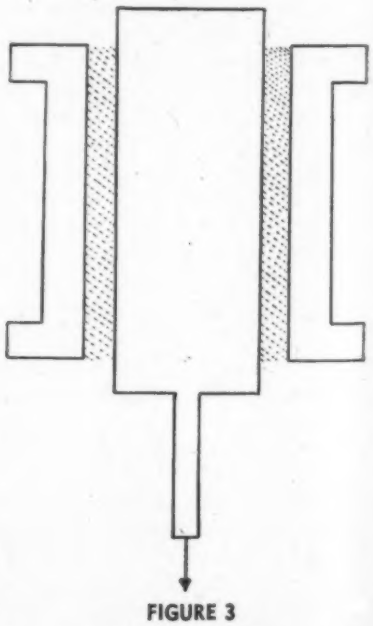

FIGURE 3

essential features of a "Couette." Viscometers of the Couette type have been used for liquids belonging to very different viscosity ranges.

Instead of a cylinder moving downwards in a cylindrical volume filled with liquid, a ball may be let to fall or a droplet (or a bubble) to rise. This method as well can be used for liquids of almost any viscosity but often is inconvenient since the rate of fall (or rise) depends on the distance between the ball and the walls of the enclosing vessel; if this distance

varies during an experiment (i.e., the ball does not move exactly parallel to the axis of the cylinder) or from one to another experiment (i.e., the track of the descending ball is not quite reproducible), the rate of descent varies as well and often so much that the method becomes unworkable. This induced Flowers[11] and Hoeppler[12] to substitute a tilted vessel for the vertical one: a tube is filled with liquid, tilted under a definite angle, and a ball is placed into it; the ball rolls down along the lower wall of the tube at a rate which depends on the viscosity of the liquid (Figure 5). The theory of the instrument is not known but it seems to be useful for comparative measurements.

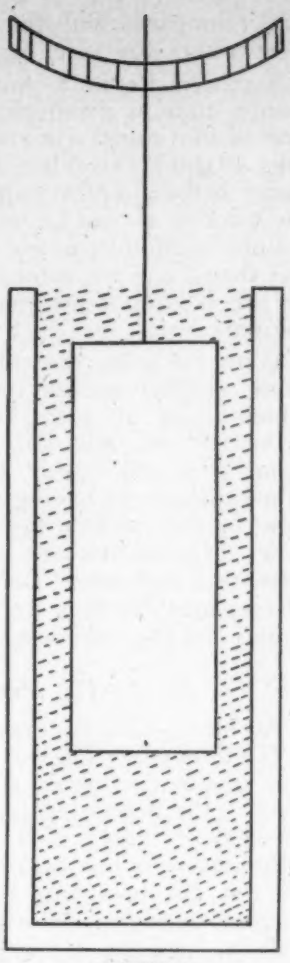

FIGURE 4

A very large number of viscometers uses the movement of liquid in stationary tubes or pipes. The manner of creating the pressure difference which drives the liquid through the tube (or a hole) can serve as a criterion for classifying viscometers of this type. In ordinary U-tube viscometers as standardized, for instance, in the A.S.T.M. test for kinematic viscosity D 445-42 this pressure difference is achieved by filling with liquid one side of the U-tube higher than the other. F. D. Farrow,[13] H. Weiss and M. Louis,[14] etc., used suction; Hess,[15]

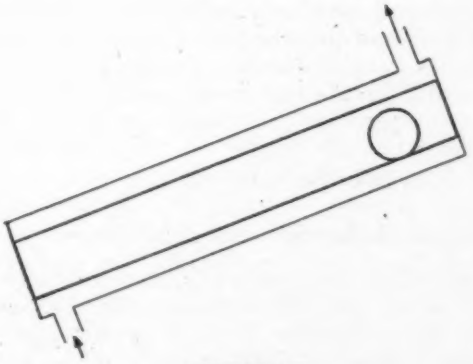

FIGURE 5

Erk[16] and others used compressed air; P. M. Giese and S. Arzoomanian[17] pushed the liquid by compressed mercury.

The fundamental difference between this kind of movement and that taking place during an axial translation of a cylinder (Figure 3) is that here every thin cylindrical layer of liquid is subjected to a force. If the liquid moves along a tube having a circular cross-section, every layer the cross-section of which is $2\pi r\,dr$ is subjected to a force $2\pi Pr\,dr$, if P means the pressure difference between the ends of the tube. If the liquid moves without acceleration this force must be counterbalanced by viscous forces. Instead of $\eta\left(\frac{du}{dr}\right)_1 r_1$ being equal to $\eta\left(\frac{du}{dr}\right)_2 r_2$, we have if L is the length of the tube.

$$2\pi L\left[\eta\left(\frac{du}{dr}\right)_1 r_1 - \eta\left(\frac{du}{dr}\right)_2 r_2\right] = 2\pi Pr\,dr \qquad (2)$$

here $r_2 = r_1 + dr$ and r_1 is the distance from the axis of the tube. From (2) the equation results

$$\frac{d^2u}{dr^2} + \frac{1}{r}\frac{du}{dr} + \frac{P}{\eta L} = 0, \qquad (3)$$

the integration of which gives the law of Poiseuille stating that the volume V of liquid transferred within the time t is equal to

$$V = \frac{\pi PR^4}{8\eta L}t, \qquad (4)$$

if R is the radius of the tube.

A careful examination of this derivation of the law of Poiseuille shows what precautions must be taken to ensure the applicability of this law. The liquid must move without acceleration. This obviously is a condition which cannot be fulfilled; without acceleration the liquid will never reach a measurable velocity at all. Still, the period of acceleration must be kept as short as possible and the final velocity must be so low that the kinetic energy of the liquid can be neglected. Unfortunately, a low velocity usually means a long experiment, and many routine tests aiming at a higher speed of testing had to violate the condition just stated. The Saybolt instrument so widely used by petroleum technologists, as well as its twin brothers in England and Germany are apt to sin in this direction if no care is taken to employ only liquids possessing a sufficient viscosity.

Another source of error common to viscometers in which the time of outflow through an orifice is determined is due to the surface tension of the liquid. Whether the liquid flows out as a stream or in drops, its surface area and consequently its surface energy increase considerably, and the rate of flow is reduced since a part of the potential energy of the liquid is transformed into surface energy instead of being consumed by internal friction.

The energy consumed by internal friction is transformed into heat within the capillary or the orifice. If the amount of this heat is considerable, it can raise the temperature of the liquid so much that its viscosity changes appreciably. This source of error is likely to be troublesome when a very viscous liquid is squeezed through a narrow capillary by a powerful plunger as, for instance, in the instruments used by Kunkler[18] and Arveson.[19] The temperature rise is the higher the higher are the pressure on the plunger and the speed of flow; de Waele[20] calculates this rise for some experiments by Arveson and finds it to be 70° C.!

When integrating equation (3) the assumption is made that the velocity of the liquid is equal to nothing at the walls of the capillary; in mathematical terms: $u = 0$ at $r = R$. In other words, we assume that the liquid does not slip along the walls. The question of whether a slippage of this kind occurs has been debated by many leading physicists of the XIX century. From the point of review of the molecular theory there is no reason why a molecule of a liquid should be unable to travel along a solid surface; on the contrary, several phenomena are known

which are best accounted for by admitting that atoms and molecules can move all over the surface of a solid. Hydrodynamic experiments on the other hand point out unmistakably to the absence of any slippage; Poiseuille's equation is invalid if a slippage existed. Apparently these hydrodynamic observations can be interpreted quite satisfactorily if it is admitted that the absence of slippage is due not so much to molecular forces as to causes of a coarser nature. All solid surfaces are rough. A liquid cannot move in a straight line along the surface as its way is obstructed by hills and valleys on the solid. An analogous effect takes place, only on an enormously larger scale, when winds pass over a broken country.

On this view the movement of liquid near the wall (near may mean anything between 0.000001 cm. and 0.001 cm, or between 0.5 and 500 microinches) is not as regular as assumed in the derivation of equation (3). But is has to be quite regular over the whole cross-section of the tube outside the thin superficial film; otherwise Poiseuille's equation cannot be applied.

The flow corresponding to equation (3) which may be visualized as sliding of thin coaxial cylinders one past another (Figure 6) is called laminar and can be realized only when a condition is fulfilled. This condition is that the Reynolds number of the flow

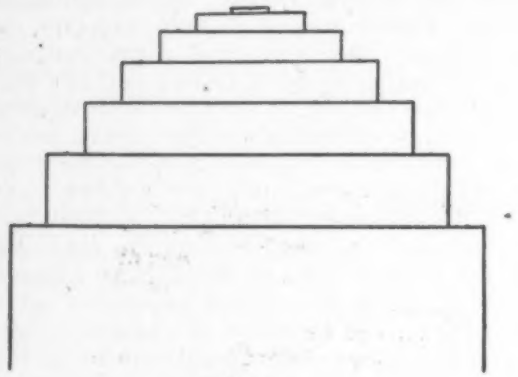

FIGURE 6

remains below a more or less definite value. Reynolds number is the ratio of inertia force to viscous force and its mathematical expression is $\frac{vR\rho}{\eta}$, v being the mean velocity of flow in the tube, R the radius of the tube, ρ the density of the liquid, and η its viscosity. When this number is great, i.e., when the velocity is too big for the viscosity given, the laminar flow is displaced by a turbulent flow in which the liquid does not move in parallel cylinders but produces waves, eddies, etc. Because of these disturbances more work or potential energy is transformed into heat and less remains to build up the kinetic energy of the liquid. Consequently the rate of discharge in the turbulent regime is less than would be in the laminar flow at the same pressure head in the same capillary.

The Reynolds number at which the laminar flow becomes unstable is usually near 1000. No precise value can be specified for it. That is partly due to the general fact that disturbances arise under less definite conditions than a regular movement does, and partly to the effect of surface roughness on the critical Reynolds number (see, e.g., Binder[21]). This number is the smaller the larger are the hills on the wall (compared with the radius of the tube) and the steeper they are (see, e.g., Goldstein[22]).

A critical Reynolds number of 1000 means, for instance, that in a tube 0.2 cm. wide (0.08 inch) the rate of movement (in cm./sec.) should not be more than 10,000 η (η = viscosity in g.cm.$^{-1}$ sec.$^{-1}$); if viscosity is 0.01 (as for water and many hydrocarbons) the velocity should be less than 100 cm./sec., i.e., the volume of liquid passing through the tube should be less than 3 c.c. per second. That is another indication of the danger associated with too rapid viscosity measurements.

With the same critical Reynolds number and the same capillary we find for a bitumen the viscosity of which is, say, 10^8 g.cm.$^{-1}$ sec.$^{-1}$ the maximum velocity to be 10^{12} cm./sec., i.e., larger than the velocity of light. It would appear, therefore, that bitumen and other substances having very high viscosities should flow in the laminar fashion whatever the speed of flow. Experiments are in a complete disagreement with this deduction. Before an explanation for this discrepancy can be sought the properties of a perfect solid must be considered.

III. Perfect Solids

A perfect solid suffers only elastic deformations. If it is indented or bent or strained in any other way, the strain disappears entirely and immediately as soon as the deforming force ceases to operate. A subdivision of these solids obey Hook's law, i.e., their deformation is proportional to the stress applied, but for our purposes only the complete reversibility of the deformations is essential.

Ordinary glass is perhaps the most perfect solid in existence. Glass fibers can be kept bent for years but become straight again as soon as they are set free. Glass rods can be stretched again and again without showing any fatigue, i.e., a change in their mechanical properties.

On the other hand there are not many substances which are so easily deformed beyond any hope of recovery than is ordinary glass.

If a steel ball is slightly pressed against glass surface, a minute depression results which disappears completely and suddenly when the ball is lifted again. But if the pressure on the ball is raised the glass, instead of becoming permanently indented, cracks; and as a rule the cracks are the more numerous and the fragments the smaller, the more "perfect" is the glass, i.e., the higher is the maximum stress which still causes elastic deformations.

IV. Time of Relaxation and Distribution of Stress

Now we may return to the case of bitumen. Some bitumen sorts, as for instance the "shoemaker's pitch" of the physicists of XIX century, behave as Newtonian liquids. If, say, a steel ball is placed on the surface of a pitch block, it gradually sinks into the pitch and continues to sink at a constant rate from which the viscosity of the pitch can be calculated as mentioned in Section II. The calculation gives viscosities of the order, say, of 10^8 g.cm.$^{-1}$ sec.$^{-1}$. On the other hand, if a similar ball instead of being gently placed on the pitch block is rapidly pressed against it, the block cracks much in the same manner as does glass, a perfect solid. Rosin plasticized with a little turpentine oil can be substituted for pitch.

How do these substances manage to behave in one

experiment as perfect liquids and in another as perfect solids? What determines their behavior, what must be done to obtain from pitch the response of a liquid or of a solid? There are more "dualisms" in physics than that of waves and particles.

An explanation, at least a formal explanation, of this dualism has been advanced many years ago by J. C. Maxwell. Suppose a stress F acts on a system and produces in it a relative deformation (strain) S; if, e.g., a wire is stretched, F (in lb. per sq. inch or in dynes/cm.^{2}) is the tension applied and S is the elongation of the wire divided by its initial length. Then according to Maxwell the ratio $\frac{S}{F}$ may be expressed in the form

$$\frac{S}{F} = \frac{1}{E} + \frac{t}{\eta}; \qquad (5)$$

E is Young's modulus of the material and t the time since the stress has been applied. If the viscosity η of the material is very high, the term $\frac{t}{\eta}$ is negligibly small, and $\frac{S}{F} = \frac{1}{E}$ as for glass. If the viscosity is very small, the term $\frac{t}{\eta}$ is much larger than $\frac{1}{E}$, and $\frac{S}{F} = \frac{t}{\eta}$; that means that the relative deformation S at a constant stress F increases with time and this increase is the slower the larger is the viscosity: as for perfect liquids.

If the applied stress F does not remain constant, instead of equation (5) an equation

$$\frac{dF}{dt} = E\left(\frac{dS}{dt} - \frac{F}{\eta}\right) \qquad (6)$$

is used. If η is very large (glass), $\frac{dS}{dt}$ is nearly equal to $\frac{1}{E}\frac{dF}{dt}$, i.e., the deformation varies in time in just the same way as does the applied stress. If on the contrary η is small, the term $\frac{EF}{\eta}$ may become larger than $\frac{dF}{dt}$ so that the rate of deformation $\frac{dS}{dt}$ is in any moment nearly proportional to the stress F operating in this moment, independently of the previous history of the sample. That is a state in which a laminar flow is possible. Equation (6) presupposes that when the relative deformation S is kept constant, i.e. when $\frac{dS}{dt} = 0$, the stress F diminishes at a rate proportional to the stress. For instance if a wire is stretched by a tension F and then kept in position by a clamp, the tension in the wire should decrease exponentially. Real bodies do not follow this rule accurately. Schwedoff[23] suggested to write $\frac{dF}{dt} = -\frac{F-Y}{\eta}$ instead of $\frac{dF}{dt} = -\frac{F}{\eta}$; the residual stress Y exists since real bodies are not perfect.

If as a first approximation Maxwell's theory is accepted, an important notion can be derived. Equation (5) easily gives

$$\frac{SE}{F} = 1 + \frac{Et}{\eta} \qquad (7)$$

The ratio $\frac{\eta}{E}$ has the dimension of time and was called *time of relaxation*, T. Hence,

$$\frac{SE}{F} = 1 + \frac{t}{T} \qquad (8)$$

If the viscosity is small (light hydrocarbons, water, etc.) T as well is small, and the second right hand term of equation (8) is important even when the duration t of experiment is short. If the viscosity and consequently the time of relaxation are large, the term $\frac{t}{T}$ is small except for very protracted experiments, and $\frac{SE}{F}$ is nearly equal to 1, i.e., we observe the behavior of elastic solids.

It appears to the writer that this reasoning due to Maxwell usefully can be supplemented by considerations based on the modern theory of strength of materials. It was said in the foregoing paragraph that when the term $\frac{t}{T}$ is small we may expect to observe the behavior of elastic solids. As the above-mentioned examples of bitumen and glass show, the behavior observed is often that of a brittle, not of an elastic solid.

It is easily visualized that a body, say a bitumen rod, breaks when at one of its cross-sections the neighboring atoms are pulled apart so far that their mutual attraction becomes negligible; hence, no special explanation is required for the observation that a bitumen rod is rapidly ruptured by an excessive load producing a large extension of the rod. But some examination seems to be needed for the fact that, if the applied load is small, the bitumen rod can be extended much further without any rupture.

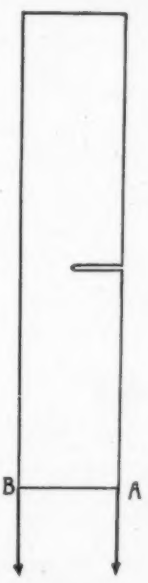

FIGURE 7

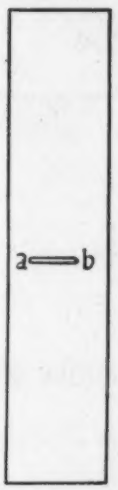

FIGURE 8

FIGURE 9

(The degree of extension which can be realized is a measure of the ductility of bitumen; see, e.g., the A.S.T.M. test D 113-39.)

The majority of physicists and technologists agree that the values of the ultimate tensile strength of real materials which are so much lower than the theoretical strength values calculated from the intensity of intermolecular forces, are due to imperfections in all ordinary solids. All "amorphous" and microcrystalline solids contain regions of broken lattice, gas bubbles, slag particles, cracks, or similar weak spots. These spots cause a concentration of stress at their edges which may exceed many times the average stress.

A general idea of the underlying mechanism may

be conveyed as follows. Consider a notched bar (Figure 7). It is obvious that a force applied at A will tend to deepen the notch with much more effect than an equal force applied at B just as the couple produced by a force is the greater the longer its arm. Something of this kind takes place also when the crack is completely within the bar (Figure 8). If the cross-section of the crack along the line ab be Q, and the average stress applied to the ends of the bar, F, then the force FQ is concentrated on a narrow ring around the edge of the crack and the tension (force per unit area) at the edge is much larger than F. It may become larger than the cohesion of the material and the crack is made to grow.

The growth of crack is the only way open to a substance having a very high viscosity. If the viscosity is not so high the bar can adapt itself to the stress applied by changing the shape of the crack or a similar process. The concentration of stress around

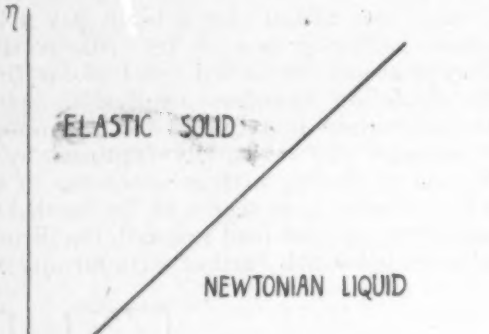

FIGURE 10

FIGURE 11

the edges of a crack is the more intense the sharper are the edges in the direction normal to the stress. If the material is so mobile that the crack of Figure 8 is transformed by the applied stress into one of Figure 9, the stress concentration is much lowered and may cease to be dangerous. In all probability the action of plasticizers is based on this effect.

The viscosity of shoemaker's pitch is very great. If to a rod of pitch a high stress is applied, it causes the present cracks and flaws to grow, and the rod is ruptured as a brittle body. If the stress applied is just too small to induce a growth of the weakest spot of the rod, the cracks and flaws will have time to adopt a more favorable shape, the rod will be "work hardened" in respect to loading and will slowly be extended under "necking."

As a result of the discussions of Sections II, III, and IV we may state that the rheological behavior of a sample, even if the material possesses a Newtonian viscosity, can be quite different according to the stress applied and the duration of its application. If the duration of application is small compared with the relaxation time, the sample will exhibit the elasticity of a perfect solid. If the duration is much larger than the time of relaxation, the sample will behave as a simple liquid. Both these statements are true as long as the stress remains below that sufficient to enlarge the weakest spot. If the stress is larger, the sample is ruptured, i.e. behaves like a brittle solid. Figures 10 and 11 give a pictorial expression to these rules.

End of Part 1—Part 2 and Part 3 will appear in succeeding issues.

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Design of Structural Details For High Towers

JESSE YEAKEL

THE literature on the structural design of high towers for the petroleum-refining industry is reasonably complete within the range of the diameter-to-height ratios now in use.

However, no structure is safer than its details, which are sometimes left to the judgment of junior members of the organization, or possibly given no serious consideration at all. The tower shell may have been carefully designed to take care of stresses due to wind pressure, internal pressure and vertical load; the foundation may have been correctly proportioned so as to distribute pressures properly to the soil; but if the anchorage of the tower to the foundation or the bearing of the tower on its base are inadequate in detail, the entire structure cannot be said to be safely designed.

It is the purpose of this article to set forth certain detail features which should be investigated before the design of a high non-guyed tower is considered completed.

A base detail for such a tower is illustrated in Figures 1 and 2.

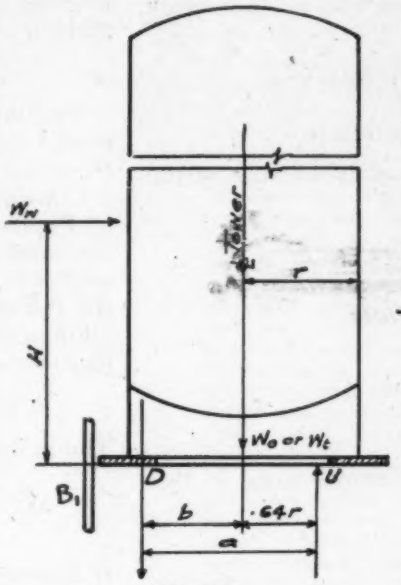

FIGURE 1

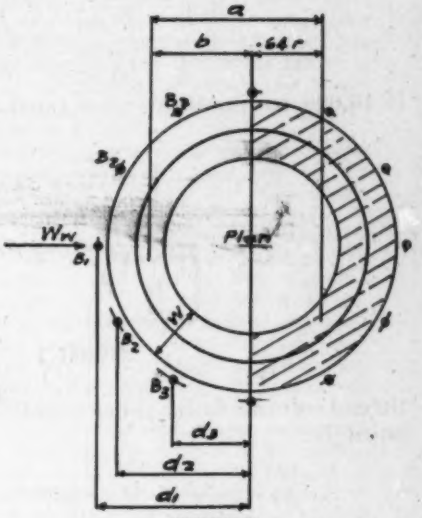

FIGURE 2

Design of Anchor Bolts

Let Figure 1 represent the forces acting at the base of the tower under wind load W_w from the left, acting at distance H from the base and causing moment W_wH. This moment is resisted by (1) the weight of the tower acting along its center line, (2) the upward reaction of the concrete acting at U, and (3) the downward pull of the anchor bolts to the left of the center line of the tower, acting through their resultant at D.

The half ring plate shown cross-hatched in the plan view, Figure 2, transmits the load at U and the center of gravity of this half ring plate is a distance .64r from the center line of the tower, r being the radius of the tower skirt and the ring plate being placed symmetrically under the tower skirt.

The line of action of the effective anchor bolts may be determined as follows:

Assume the radius of bolt circle 6 inches greater than the radius of the tower skirt to bring the bolts outside of the ring plate; lay out 8 bolts equally spaced on this radius for medium height towers and 12 bolts for higher ones. Then, assuming a 12-bolt layout is chosen (see Figure 2), calculate dimensions d_1, d_2, and d_3. The force exerted on each bolt is proportional to its distance from center line of tower. If bolt B_1 is distant d_1 from center line, B_2 distant d_2 from center line, and B_3 distant d_3 from center line, then the force on bolts B_2 and B_3 expressed in terms of the force on bolt B_1 may be written as follows:

$$\frac{B_2}{B_1} = \frac{d_2}{d_1} \text{ and } \frac{B_3}{B_1} = \frac{d_3}{d_1} \text{ or: } B_2 = \frac{B_1 d_2}{d_1} \text{ and } B_3 = \frac{B_1 d_3}{d_1}$$

and the moment of the bolt forces about center line of the tower will be:

$$B_1 d_1 + \frac{2B_1 d_2^2}{d_1} + \frac{2B_1 d_2^2}{d_1} + \frac{2B_1 d_3^2}{d_1}$$

Multiplying the first term by $\frac{d_1}{d_1}$ and re-arranging, this expression becomes:

$$B_1 \left(\frac{d_1^2 + 2d_2^2 + 2d_3^2}{d_1} \right) \qquad (1)$$

The sum of these bolt forces, also expressed in terms of B_1 is:

$$B_1 + \frac{2B_1 d_2}{d_1} + \frac{2B_1 d_3}{d_1} \text{ or } \frac{B_1}{d_1} (d_1 + 2d_2 + 2d_3) \qquad (2)$$

The distance from the center line of the tower to the center of gravity of the bolt forces is (1) divided by (2) or:

$$b = \frac{d_1^2 + 2d_2^2 + 2d_3^2}{d_1 + 2d_2 + 2d_3} \qquad (3)$$

and $$a = b + .64r$$

Now take moments about point U, Figure 1:

$$W_w H - .64 W_o r - Da = 0$$

Then: $$D = \frac{W_w H - .64 W_o r}{a} \qquad (4)$$

Example

Assume a tower 8 feet in diameter; 160 feet high, with a wind force of 38 kips acting at 80 feet above

the base; weight of tower empty (W_o) is 80 kips; weight of liquid is 70 kips; total weight (W_t) is 150 kips; radius of bolt circle is 4.5 feet.

Then $d_1 = 4.5$; $d_2 = 3.9$ and $d_3 = 2.25$.

Substituting these values in (3):

$$b = \frac{4.5^2 + 2 \times 3.9^2 + 2 \times 2.25^2}{4.5 + 2 \times 3.9 + 2 \times 2.25} = 3.62 \text{ ft.}$$

Then: $a = 3.62 + .64 \times 4 = 6.18$ ft.

Substitute known values in (4):

$$D = \frac{(38 \times 80) - (.64 \times 80 \times 4)}{6.18} = 459 \text{ kips.}$$

This force is exerted on the five anchor bolts shown in Figure 2, and we already have, in (2), an expression for it in terms of the force on bolt B_1. Therefore we may write:

$$B_1 \left(\frac{d_1 + 2d_2 + 2d_3}{d_1} \right) = 459 \text{ kips,}$$

$$\text{or: } B_1 = \frac{459 \times d_1}{d_1 + 2d_2 + 2d_3} = 123 \text{ kips.}$$

If 15,000 psi is allowed for tension at the root of the

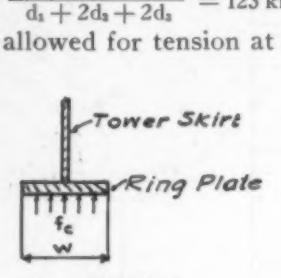

FIGURE 3

thread of the bolt, then a bolt whose area at this point is:

$$\frac{123}{15} = 8.2 \text{ sq. in. is required.}$$

A bolt 3¾ inches in diameter gives 8.6 square inches.

The anchor bolts should extend into the foundation at least far enough to develop the value of the bolt in bond with the concrete, or some other means of engaging the concrete should be devised. If the anchor bolt is set in a sleeve, the depth of the sleeve should be deducted to arrive at the distance available for bond.

In the example given, the perimeter of the 3¾-inch bolt being 11.8 inches and bond taken at 120 psi, the amount of bond developed per foot is: 120 x 11.8 x 12 = 17 kips. The amount of imbedment required to develop 123 kips would be:

$$\frac{123}{17} = 7.2 \text{ feet,}$$

which should be measured from the bottom of the sleeve in which the bolt is set. A hook or welded washer should be added at the bottom for safety. A bolt carrying a load of this amount should have two nuts at the top.

The lugs on either side of the bolt directly under the nut should be long enough to allow space for sufficient weld to transfer the stress in the bolt to the tower skirt. In this connection, it should be remembered that although the first of the two lugs at each bolt has a weld on each side, the inner weld of the second lug is difficult to make. It would therefore be safer to count only one weld on each lug.

In the example cited, if a weld were chosen good for 3000 pounds per inch of weld, the length of lug required would be:

$$\frac{123}{2 \times 3} = 20.5 \text{ inches}$$

Design of Ring Plate

Take moments about D, Figure 1:

$$W_w H + W_t b - Ua = 0 \text{ or:}$$

$$U = \frac{W_w H + W_t b}{a} \quad (5)$$

Note here that W_t, the weight of the tower plus the liquid, is taken instead of W_o, the weight of the tower alone, which was used when anchor bolts were designed.

The area of the part of the ring plate shown cross-hatched in Figure 2 must be great enough to spread the load U over enough concrete so that the bearing value of the concrete will not be exceeded. If this bearing value is f_c and the area of the cross-hatched plate is A, then:

$$A = \frac{U}{f_c} \quad (6)$$

The thickness of the ring plate must be such that it will spread the load radially inward and outward from the tower skirt.

Consider a section through the ring plate shown in Figure 3. Let w be the width of the ring plate in the same linear unit as f_c, and let the length at right angles to the section be one of these units. Neglecting the thickness of the tower skirt, each side of the ring plate acts as a cantilever of length w/2 with a total load of:

$$f_c \times \frac{w}{2}$$

The moment in the ring plate under the skirt will be:

$$M_r = \frac{f_c \times \frac{w^2}{4}}{2} = \frac{f_c w^2}{8} \quad (7)$$

If f_s is the flexural stress in the plate, it will develop a moment

$$M = f_s \times \frac{I}{c} \quad (8)$$

where I/c is the section modulus of the plate.

Equating (7) and (8):

$$f_s \times \frac{I}{c} = \frac{f_c w^2}{8} \text{ or } f_s = \frac{f_c w^2}{8 = I/c} \quad (9)$$

It is now possible to determine the width of the ring plate in the example already begun. It will be recalled that the radius of the anchor bolt circle was taken as the radius of the tower skirt plus 6 inches, and that the diameter of the anchor bolts is 3¾ inches, which limits the distance from the skirt to the outer edge of the ring plate to 4⅛ inches. To allow clearance, reduce this to 4 inches, giving a plate 8 inches wide. The area of half of the ring plate, the portion shown cross-hatched in Figure 2, will be the area of the half-circle to the outer edge minus the area of the half-circle to the inner edge, or 1206 square inches.

Substituting known values in (5):

$$U = \frac{(38 \times 80) + (150 \times 3.62)}{6.18} = 579.8 \text{ kips.}$$

Writing (6) in the form $f_c = \frac{U}{A}$ and substituting known values:

$$f_c = \frac{579{,}800}{1206} = 481 \text{ psi,}$$

and the assumed width of plate is satisfactory.

Assuming a plate 1¼ inches thick and applying (9),

$$f_s = \frac{480 \times 64}{8 \times .26} = 14.77 \text{ kips or } 14{,}700 \text{ psi.}$$

Compression Distillation

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Arthur D. Little, Inc., Cambridge, Massachusetts

THE possibility of attaining unusually high fuel economy in distillation by using the compression method has been recognized for many years, but not until World War II was this method widely used.

Fundamentally the high fuel economy of this process depends upon compression of the vapor leaving the evaporation compartment so that it can be used in the steam chest in place of process steam. The most recently developed units for distillation of sea water are capable of producing 175 pounds of distilled water for each pound of fuel consumed. This represents what is believed to be the highest fuel economy of any practical system of evaporation, with the exception of solar evaporators and systems which are tied into other plant operations, as in the case of a "reducing valve evaporator."

Practical application of this principle using jet compressors was attempted as early as 1856.[1] In 1881, Jules Weibel of Geneva, Switzerland, obtained a patent[2] which discloses the use of a reciprocating compressor for this purpose. The earliest American inventor in this field appears to have been Addison G. Waterhouse of Highland Park, Connecticut, who secured a patent[3] in 1897. Development of this art was very slow until after World War I, when a few custom-built commercial installations were successfully made by two or three European firms. No American industrial applications of mechanical compression distillation are noted in the literature, or known to the author.

Shortly before World War II, intensive development of compression distillation as applied to the production of distilled water from sea water was undertaken at the laboratories of Arthur D. Little, Inc., under the vigorous leadership of Dr. R. V. Kleinschmidt (now Commodore Kleinschmidt, USNR), who was first to advocate mechanical compression distillation for Naval and other military uses. His first experimental unit operated so well that officials of the Armed Services were called in for a demonstration. Sensing the strategic significance of the Kleinschmidt unit, these officials actively promoted its development for a specific application. This and subsequent models were manufactured by E. B. Badger and Sons Company of Boston under cooperative arrangement with Arthur D. Little, Inc. The performance of the Kleinschmidt units in their early applications was so encouraging that even before the attack on Pearl Harbor three specialized units were under development for the Armed Forces. There is now enough Kleinschmidt compression distillation equipment in service to produce pure distilled water for the daily needs of over a million men. This wide acceptance grew from outstanding performance, particularly with respect to economy of fuel and ease of operation. Devices and methods used in this advance of the art are covered by a number of United States and foreign patents and patent applications assigned to Arthur D. Little, Inc.

ALTHOUGH this paper deals with application of compression distillation to water distillation, its adaptation to other processing is evident. The paragraph below has been taken from an anlysis of the article for use as a summary. The paper was presented before the Power Division of the American Society of Mechanical Engineers in New York, November 27, 1945.

"Compression distillation depends upon mechanically compressing the steam or other vapor leaving the evaporation compartment of the still. This compression raises the temperature of the steam a few degrees. At the higher pressure, the steam condenses at a temperature somewhat higher than the boiling point of the evaporating raw water, so that heat can flow from the condensing steam to the raw water and boil it. In engineering terms, the condensing vapor is used to supply heat inside the steam chest of the still in place of steam from sources outside the unit. Efficient provision for reducing heat loss to the atmosphere and recovering heat from the distillate and the concentrate carrying out waste as they cool down to room temperature completes the system. No separate condenser or cooling water is needed. The overall fuel economy of the most recent Kleinschmidt compression stills—averaging at least 175 pounds of distillate for each pound of fuel consumed—is believed to be the highest of any self-contained system of evaporation."

It appears likely that there is a much broader field of practical application for compression distillation than in the production of distilled water. In order that more engineers may have a well founded understanding of this process, the remainder of this article is devoted to an introduction to the significant engineering characteristics of compression distillation.

Figure 1 is a diagrammatic representation of this process as applied to the production of fresh water from sea water. Normal operation is preceded by a period of heating to bring the apparatus and its contents to operating temperature. As soon as the evaporator has been filled with steam, the still may be turned on stream for continuous operation. The sea-water feed enters by way of a triple passage liquid-to-liquid heat exchanger which extracts heat from the outgoing distillate and brine to heat the feed. The feed at about 207° F. is then introduced to the evaporator where it mixes in a relatively large volume of brine which circulates by natural circulation through the vertical tubes. Steam at, or slightly above, atmospheric pressure is led from the evaporation space through an entrainment separator to the compressor which raises the pressure to about 3 pounds per square inch gauge, thus raising its saturation temperature to about 222° F. Since the brine in

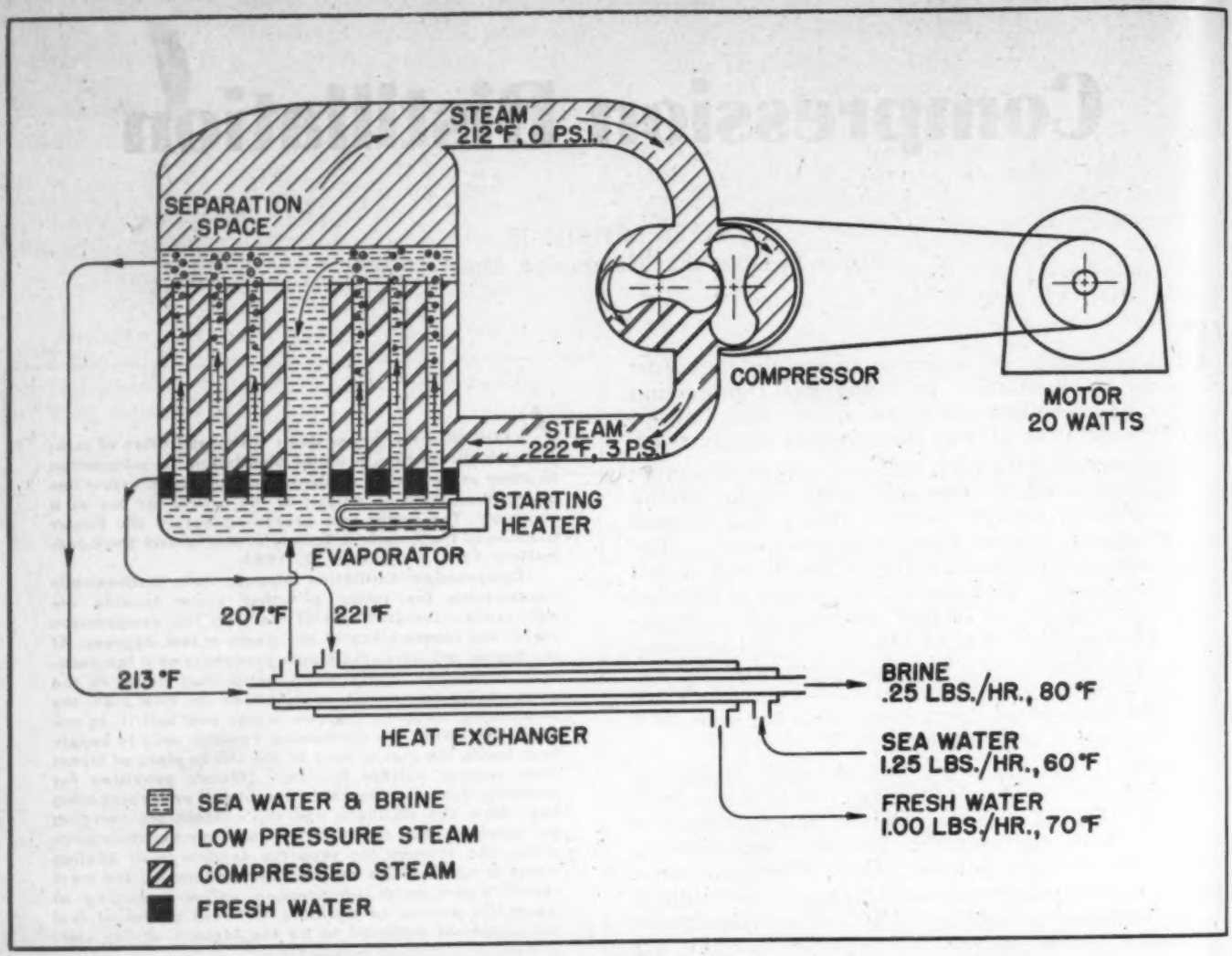

FIGURE 1

Diagramamtic representation of compression distillation as applied to distillation of sea water.

Recent Kleinschmidt compression-distillation unit. This gasoline-engine model produces 1800 gallons of distilled water per day from sea water.

the evaporation space boils at about 213° F., there is a temperature differential of about 9° F. between the compressed steam and the boiling brine to permit transfer of heat from the former to the latter. Substantially all of the latent heat of the compressed steam is used in maintaining evaporation in the evaporation space; thus no separate condenser or cooling water is required. With a unit of 1000 gallons per day capacity, the production of 1 pound per hour of distillate requires an electric power expenditure of about 20 watts. To produce the same amount of distillate in a single-effect evaporator would require approximately 300 watts. From this it is apparent that the Kleinschmidt Compression Distillation Process as applied to sea-water distillation has an eco-

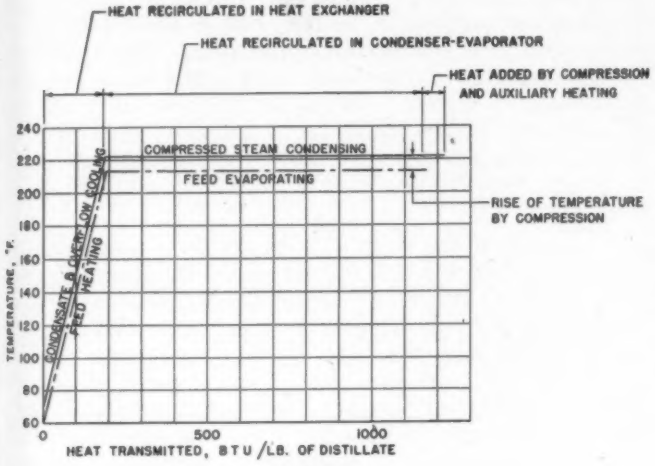

FIGURE 2

Temperature-heat quantity relationship in compression distillaltion unit.

nomy equivalent to some 15 or more effects. Furthermore, a compression-distillation unit is far more simple to operate than a multiple-effect unit. The connections, heat transfer apparatus and controls are as simple as those on a single-effect evaporator. Ordinarily, control of the operation is made entirely through adjustment of the flow of feed only. That this process requires very little operational attention is evidenced by the fact that on shop tests units set up for manual control have been left running day and night for as long as a week without adjustment of any sort.

* * *

A more complete understanding of the basic principles of this process may be obtained through a study of the relationship between the heat quantities and temperatures throughout the process. Figure 2 is a graphical representation of this relationship. Construction of this diagram is based on the usual consideration of heat balance. Cold feed entering at 60° F. is heated (inclined dot dash line) to 207° F. by heat exchange with the outgoing condensate and overflow (inclined solid line). Following final heating in the evaporator from 207° F. to 213° F., the hot feed is vaporized (horizontal dot dash line) by heat exchange with the condensing compressed steam (horizontal solid line). It is clearly evident that at all points in the process a suitable temperature differential exists to permit the exchange of heat from the condensate and overflow for preheating the feed and from the condensing compressed steam for evaporating the feed. The temperature differentials indicated are 10° F. in the heat exchanger and 9° F. in the condenser-evaporator. The diagram shows an excess of heat on the high temperature side (right-hand end of horizontal solid line) which allows for heat loss from the process to the surroundings through the insulation and for an operating margin. For instance, the operation of the process may be stabilized by allowing a portion of this excess heat to pass from the process, automatically venting a small amount of steam to the atmosphere. For this purpose the low-pressure steam separating space is often connected to the atmosphere through a breather vent. As indicated by the diagram, which is based on a capacity of 1000 gallons per day, the total excess heat allowed for insulation losses and stabilization losses may be of the order of 55 Btu per pound of distillate. It may be noted also that by adding 68 Btu to the process at the compressor, not only is this excess supplied, but also a temperature differential of 9° F. is created for operation of the condenser-evaporator. In this manner heat is recirculated to the extent of 960 Btu in the condenser-evaporator, and 190 Btu in the heat exchanger. Thus, the 68 Btu added at the compressor serves to circulate a total of 1160 Btu per pound of distillate, as well as supplying a surplus of heat for operational leeway. It is of interest to note that for this cycle where all-electric drive is used, the efficiency of the steam compressor need not be high. The amount of energy required for this compression ideally would be only about 15 Btu compared with the 68 Btu which on moderate-sized units has been found practical. Actually, the full 68 Btu is not ordinarily added entirely at the compressor. Perhaps 35 Btu is put in at this point and

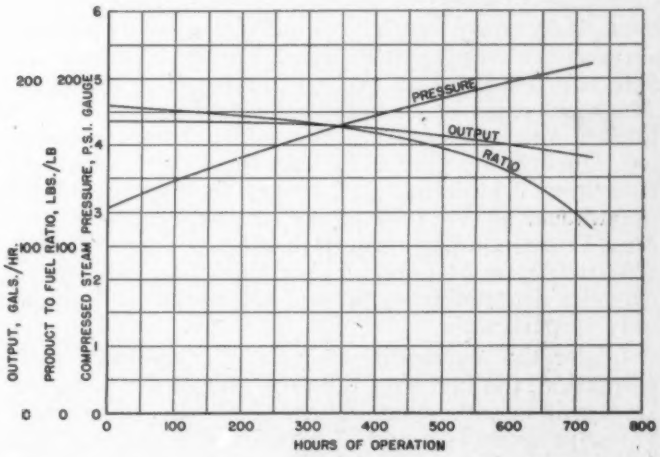

FIGURE 3

Performance of gasoline-engine-driven compression distillation unit.

the rest is added by use of electric heaters in the evaporation zone.

As in many evaporation processes, the compression-distillation process is usually affected by scale formation on the evaporation surface. In some ways the effect of scale formation on the performance of a compression evaporator is more noticeable than on more conventional types. The added resistance to heat transfer produced by scale requires an increase in compressed-steam pressure in order to maintain constant output. This results in more energy entering the system by way of the compressor. In an all-electric drive, the added energy input from the compressor may be compensated for by a decreased use of the electric heater, thereby maintaining a practically constant total electrical input regardless of

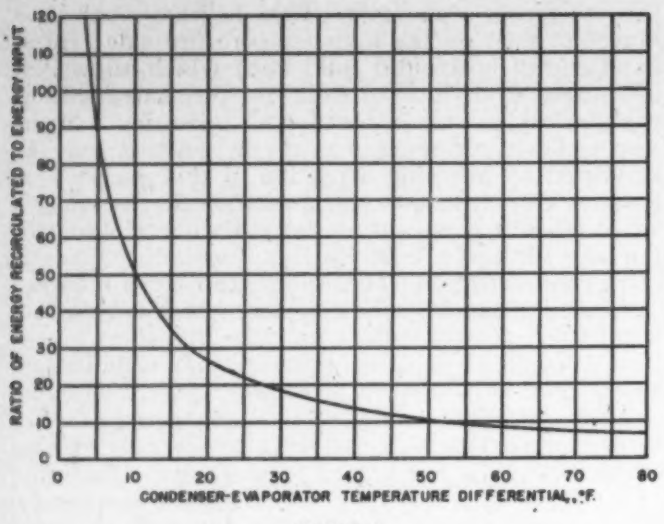

FIGURE 4

Calculated performance of compression distillation process.

scale formation. A rather different situation exists in the case of an internal-combustion-engine drive equipped for waste-heat recovery. In this case, the waste heat is more than sufficient to perform the same function as the electric heaters in an electric drive. Scale formation leads to a heavier load on the engine, which in turn gives up more waste heat, which of course is not needed for operational leeway. Thus the engine-driven unit has a characteristic of low fuel consumption when the evaporator is clean, and gradually increasing fuel consumption as scale formation progresses. In spite of this, however, the overall economy of the engine drive is difficult to surpass with any other drive. Figure 3 shows the field test results of an experimental unit of this type. The evaporator was started clean and operated for a total of 730 hours before being shut down for cleaning. During this time the compressed steam pressure rose from 3.1 pounds per square inch gauge to 5.3 pounds per square inch gauge, an increase of 71 percent. Corresponding drop in product to fuel ratio was 185 to 122, or 34 percent. For this same period the capacity dropped from 169 to 152 gallons per hour, or only 10 percent.

Under the above discussion of the effect of scale formation, the fact that the economy of the compression unit is somewhat governed by the compressed vapor pressure is noted. A broader exposition of this relationship is presented in Figure 4 for the purpose of more fully defining the limits of appliaction of the compression principle. These calculations are based on thermodynamic properties of steam. Similar relationships, of course, could be calculated for other vapors. Temperature differential rather than pressure differential is used as the criterion because the resultant curve applies over a broader range of conditions. For instance, if the evaporator pressure is held at 10 pounds per square inch gauge instead of 0 pounds per square inch gauge, the theoretical energy requirement for maintaining 10° F. differential between the condenser and evaporator will be practically unaffected, whereas the pressure differential will increase some 65 percent. For purposes of calculation, the efficiency of the steam compressor is assumed as 75 percent on an adiabatic basis. The denominator of the ratio "energy recirculated over energy input" is the energy delivered to the compressor shaft expressed in heat units.

In practical applications, a wide variety of prime movers or drives for the compressor may be used, and since these cover a wide range of thermal efficiencies, the overall ratio of heat recirculated to heat input must be calculated for each individual application. With further reference to Figure 4, it is pertinent to note that most compression-distillation equipment developed thus far has been in capacities less than 250 gallons per hour. In such a unit, the amount of heat required for insulation losses and alowance for operability has been the governing factor in determining the heat input. This means that these units operate at points well to the left of the curve in Figure 4, about at the intersection of the 10 degree differential line with the 15 ratio line. With large units and conditions typical of industrial practice, a much closer approach to this curve should be possible. For any particular application, the optimum design may be determined only after careful consideration of a great variety of factors, such as the relationship represented by Figure 4, the cost of heat-transfer surface, the cost of insulation, the cost of power and the limitations of available steam compressors.

Progress in development of compression distillation has always been hindered by lack of suitable compression equipment. Development of compression equipment for this purpose is still by no means complete. Ordinarily, the high quality standards for the distillate rule out the use of any lubricant in the compression space. In fact, this requirement not only makes it impossible to use the most readily available types of compression equipment, but also requires that whatever equipment is used must be specially fitted with seals to prevent the passage of lubricating oil from the working parts into the compression space. Furthermore, the gradual rise in pressure caused by scale (see Figure 3) conflicts with the basic characteristics of centrifugal and axial-flow compressors, so that if these types of compressors are to be used, some means of frequently removing scale or of compensating for the pressure rise would be necessary. Thus the choice for many applications is narrowed down to positive displacement compressors which operate without oil in the compression space. Possibly the Connersville type blower is the best known of the types which fall within these requirements. In fact a great many Connersville machines are being used in this service today. However, for distillate production of over 300 gallons per hour per unit, the Connersville type of machine does not show promise of being readily adaptable. Current development of improved types of compressors may make a wider choice of satisfactory compression equipment possible in the near future.

The extensive application of compression distillation in military operations has demonstrated it to be thoroughly practical and outstanding economical of fuel. Indeed, the experience gained through these applications has led to the realization that the original goals, which initially appeared extremely difficult, were too modest. Today, the status of the compression-distillation art is sufficiently advanced to justify its recognition as a radically new factor in the field of distillation and evaporation.

REFERENCES

[1] Webre, Alfred L., and Robinson, Clark S., "Evaporation," p. 93; Chemical Catalog Co., New York, 1926.

[2] U. S. Pat. No. 236,657.

[3] U. S. Pat. No. 585,943.

Commercial Synthesis of Toluene By Hydroforming, and Recovery By Azeotropic Distillation

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Union Oil Company of California

PRIOR to the entrance of the United States in World War II, nitration grade toluene for the production of TNT was obtained in relatively small quantities from numerous coke-oven operations throughout the country. Because this production was a by-product related to the mining and utilization of coal, it was impossible to economically and quickly increase the quantity of toluene from this source. To bridge the gap between a supply of 28,000,000 gallons per year and a demand of over 200,000,000 gallons per year, the hydroforming process developed by The M. W. Kellogg Company in peacetime for the desulfurization and octane improvement of motor gasolines was immediately available for the job of producing toluene from selected petroleum fractions. Therefore, at the request of Army Ordnance the petroleum industry undertook to supply the bulk of the nation's wartime toluene. By late 1942 the terminology of gallons per day per coke-oven plant had been changed to the more familiar refinery expression of barrels per day per toluene unit.

This paper was presented before California Natural Gasoline Association, October meeting, 1945.

AT UNION Oil Company's Oleum refinery a Hydroforming Unit for the treating of motor gasoline was put into initial operation in the fall of 1941. Concurrent with the design and erection of the commercial hydroformer, the research department of Union Oil Company was investigating azeotropic distillation* and in particular its application to the recovery and purification of toluene from hydrocarbon fracsions produced by hydroforming. By January, 1942, ground was broken for a plant to recover toluene from hydroformate. By January, 1943, the plant was in operation and shortly thereafter was producing 600 barrels per day of nitration-grade toluene.

Feed Stock for Synthesis of Toluene by Hydroforming

Figure 1 shows the structural formula, boiling point, and gravity of the hydrocarbons associated with toluene synthesis and recovery. Dimethylcyclopentane, methylcyclohexane, and ethylcyclopentane are the three chief 'synthesis compounds" from which toluene can be synthesized in a hydroformer. Dimethylcyclopentane and ethylcyclopentane are five-carbon-ring naphthenes which are first isomerized to methylcyclohexane, a six-carbon-ring naphthene, and then dehydrogenated to toluene. Toluene is made up of the six-carbon benzene ring with one of the hydrogens replaced by a methyl group. Going from the naphthene to the aromatic in the same boiling range, there is a decrease in gravity of between 25° and 40° API. This change in gravity is sometimes used analytically to determine the approximate toluene content of a given sample. Normal heptane and dimethylhexane are two typical paraffin hydrocarbons contained in the feed stock along with the previously mentioned reactants. These compounds pass through the hydroformer reactor essentially unchanged and consequently contaminate the raw synthetic toluene hydroformate. To remove these paraffins in the toluene-recovery step, the azeotrope-former methyl ethyl ketone-water is used. This compound, an oxygenated derivative of butane, boils at 175° F., considerably below that of the paraffins and toluene in the hydroformate. The constant-boiling mixture (164° F.), approximately 90 percent MEK, 10 percent H_2O, has the property of loosely combining and lowering the boiling point of the paraffins and naphthenes contained in the hydroformate and at the same time not affecting the aromatic toluene.

All of the hydrocarbons shown in Figure 1 except MEK are contained in California crude oil and natural gasoline. Figure 2 illustrates the volume of DMCP, MCH, ECP and toluene present in Los Angeles Basin crude. The synthesis hydrocarbons total 1.45 percent of the crude, and naturally occuring tolu-

* George Lake, June 25, 1945, AIChE Transactions.

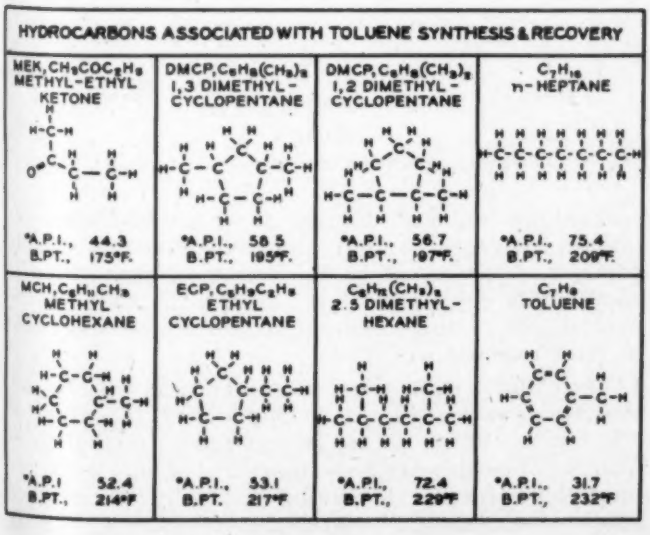

FIGURE 1
Hydrocarbons associated with toluene synthesis and recovery.

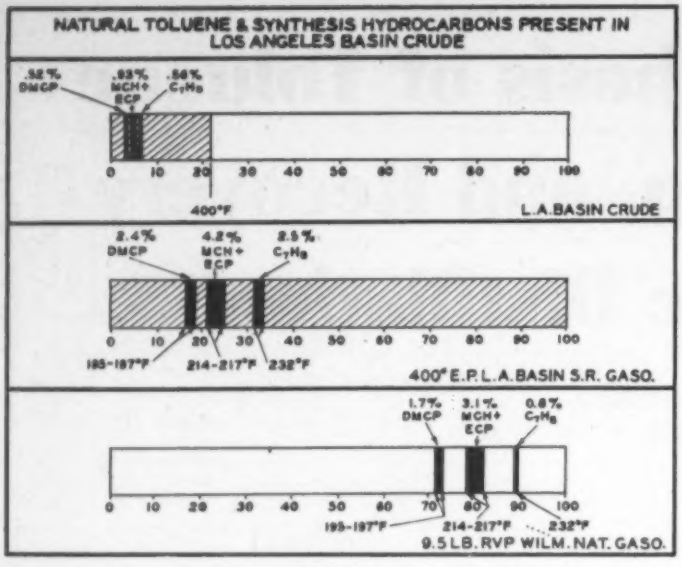

FIGURE 2
Natural toluene and synthesis hydrocarbons present in Los Angeles Basin crude oil.

ene is equal to .56 percent of the crude. Also shown on Figure 2 are typical analyses of 400° EP Los Angeles Basin straight-run gasoline and 9½ pounds Reid-vapor-pressure Los Angeles Basin natural gasoline. It can be seen that, in order to include both the synthesis compounds and naturally occurring toluene in the feed stock, a fraction containing everything boiling between about 190° F. and 235° F. must be separated from both the straight-run and natural gasoline. At Union's Los Angeles refinery this was accomplished by first taking overhead in a crude tower everything boiling to about 235° to 240° F. and then redistilling this fraction in a 30-plate tower, taking overhead everything boiling below 190° to 195° F., and thus removing from the bottom a fraction boiling between 190° and 240° F. ASTM which on a TBP distillation boils between 160° and 280° F. This operation, commonly called heart cutting, was also carried out at Union's Oleum refinery in order to make available the maximum volume of hydroformer feed stock obtainable from total crude and natural-gasoline runs by the company.

In operating a heart-cut tower, it is not possible

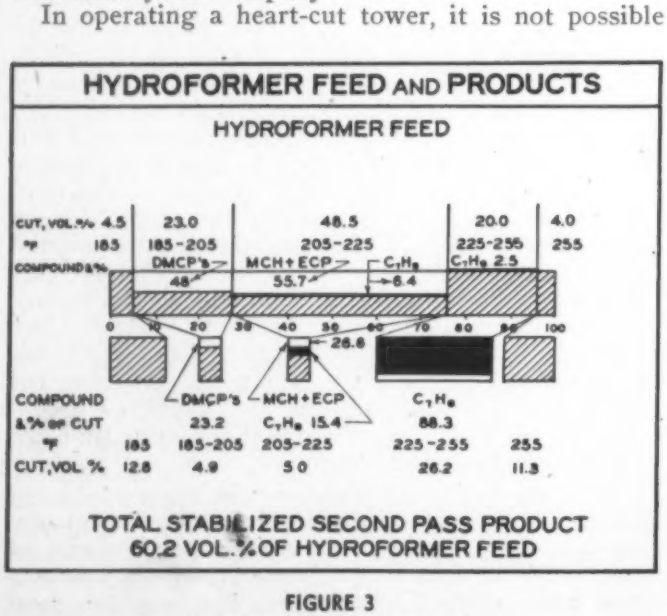
HYDROFORMER FEED AND PRODUCTS
HYDROFORMER FEED
CUT, VOL.% 4.5 23.0 48.5 20.0 4.0
°F 185 185-205 205-225 225-255 255
COMPOUND & % DMCP's MCH+ECP C7H8 C7H8 2.5
48 55.7 6.4
26.8
COMPOUND DMCP's MCH+ECP C7H8
& % of CUT 23.2 C7H8 15.4 88.3
°F 185 185-205 205-225 225-255 255
CUT, VOL % 12.8 4.9 5.0 26.2 11.3
TOTAL STABILIZED SECOND PASS PRODUCT
60.2 VOL. % OF HYDROFORMER FEED

FIGURE 3
Hydroformer feed and products.

to set up tower-temperature controls accurately by means of simple Engler distillations, because the paraffin-naphthenic type hydrocarbons have in themselves an azeotropic effect to aromatics. The boiling point of toluene is suppressed. By means of a true-boiling-point distillations carried out in high-temperature Pod apparatus followed by ultimate hydrocarbon analysis, it is possible to determine ultimate distillation-column controls in order that all of the synthesis compounds and toluene may be recovered and at the same time exclude contamination of fractions boiling above and below the desired fraction.

Referring to Figure 3, we see a typical true-boiling-point analysis of the hydroformer feed. This fraction includes essentially 100 percent of the synthesis compounds and toluene occurring in the crude.

The Hydroforming Synthesis

Again referring to Figure 3, we see the change in composition of the hydroformer feed stock after it has been passed through the hydroformer twice. A loss in liquid volume of 40 percent has occurred. This is because of the reduction in volume caused by the increased gravity of the toluene, large production of gas high in hydrogen content, and coke deposition on the catalyst. Approximately 94 percent of the synthesis compounds DMCP, MCH, and ECP have disappeared. The toluene content has of course increased at their expense.

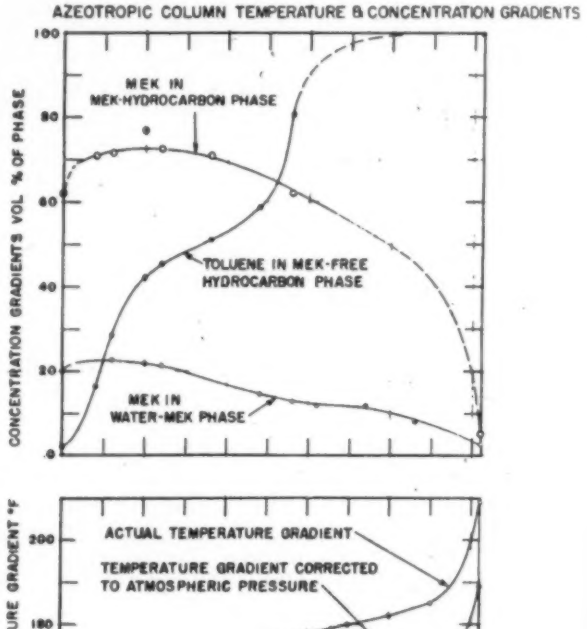

FIGURE 4
Chemical equations for toluene and coke formation.

The chemical equations for toluene and coke formation are shown in Figure 4, Dimethylcyclopentane or ethylcyclopentane is first isomerized to methylcyclohexane. The isomerized material, along with the methylcyclohexane occurring naturally in the feed stock, loses one of the hydrogen on each of the six carbon atoms making up the naphthenic ring. Upon loss of hydrogen, the unsaturated benzene ring is pro-

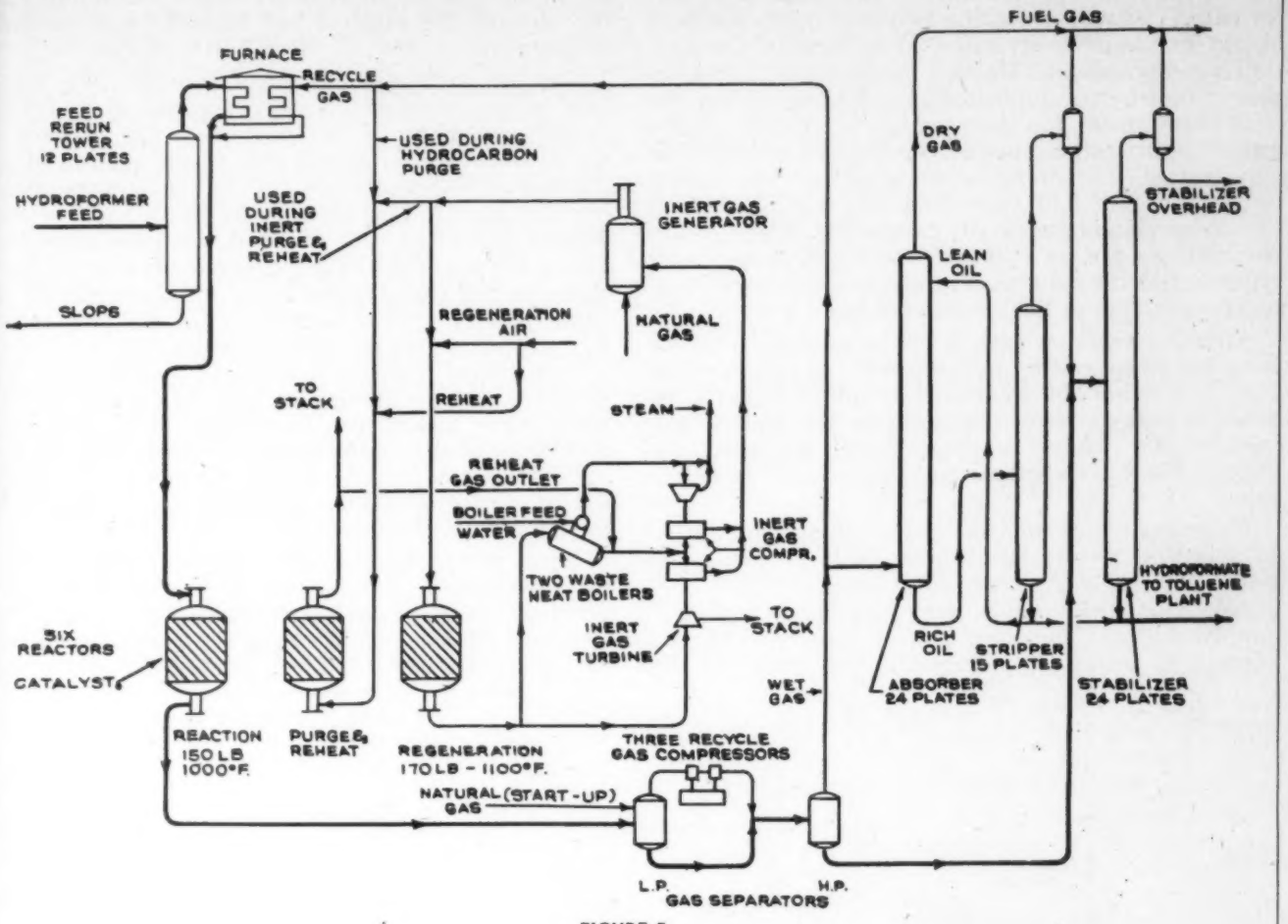

FIGURE 5
Hydroformer diagrammatic flow sheet.

duced. This reaction results in the production of hydrogen. Some thermal reforming occurs, and consequently in addition to hydrogen the dry gas contains methane, ethane, and propane. Continued dehydrogenation and condensation or polymerization of toluene results in the production of coke. Diagrammatically, this is illustrated by X molecules of toluene condensing to form a very large coke molecule plus additional hydrogen. It is this latter reaction that makes the process for producing toluene by hydroforming so complicated. The coke deposits on the catalyst, deactivating same and necessitating its regeneration.

Synthesis conditions in the commercial hydroformer are as follows:

(1) Reaction pressure of 150-300 pounds.
(2) Reactor charge temperature 1000-1070° F.
(3) Wet gas recirculation (70 percent hydrogen) 6000 cubic feet per barrel of reactor charge.
(4) Dehydrogenation catalyst consisting of 10 percent molybdenum dioxide on alumina at a space velocity defined as

$$\frac{\text{Volume of feed/hour/reactor}}{\text{Volume of catalyst in reactor}} = \text{V/V} = .6.$$

The commercial hydroformer is designed to run up to 9000 barrels per stream day of charge stock. Because it is necessary to regenerate the catalyst, multiple reactors are employed, and in the case of Union's hydroformer a total of six are used.

Figure 5 is a diagrammatic flow sheet of the hydroformer. The charge stock enters the plant, is stripped at 170 psig with 150 cubic feet per barrel of recycle hydrocarbon gas to remove traces of oxygen which would otherwise cause exchanger fouling, redistilled to reduce furnace coke deposition, preheated by exchange with reactor product, then heated and totally vaporized at 1050° F., joined with the recycle gas which has been heated to 1070° F., passed through two reactors in parallel with a time contact of about 15 seconds, out of the reactors through heat-exchange equipment and put into a gas-liquid separator. A majority of the separated wet gas, approximately 48,000,000 feet a day, is compressed by three 1000-horsepower gas-engine-driven compressors from 75 to 200 psig and recirculated back through the heat-exchange equipment, through the heater, and back into the reactor. The purpose of the wet-gas recycle is to increase the hydrogen concentration in the reactor in order to reduce coke deposition and thus maintain catalyst activity. The wet gas and liquid production passes into a conventional stabilizing and absorption plant to produce fuel gas, 170-EP gasoline, and hydroformate. The hydroformate, if first pass (that is, first time through the hydroformer), goes to stor-

age. At about the end of two weeks the first-pass production is blocked back through the hydroformer, resulting in the production of second-pass hydroformate. The reason for the two-pass operation is to obtain maximum conversion to toluene of the synthesis compounds. In Union's particular hydroformer this cannot be accomplished in one step because the heat requirement for the reaction is so great that a reduction in temperature across the bed of 150° F. is experienced. The first-pass material is consequently only about one-half converted. On second passing the conversion is essentially completed. While two of the reactors are on reaction, three others are being regenerated. The sixth is either being prepared to go on regeneration or back onto reaction.

After the reaction period, the remaining hydrocarbons are swept out by purging with wet-gas production. Following the hydrocarbon purge step the reactor is purged with inert gas. At the end of nine minutes the reactor has been completely purged of vaporizable hydrocarbons and is ready for regeneration.

Regeneration of the coked catalyst is accomplished by bleeding 190-pound air into an inert gas, essentially N_2 and CO_2, circulating stream. Two 3000-horsepower steam-driven reciprocating compressors supply the air. The inert gas at controlled oxygen content of about 1½ percent passes down through the reactors on regeneration; the oxygen combines with the coke to form carbon dioxide and water; the inert gas removes the heat of combustion and in passing through the catalyst bed is raised from an inlet temperature of 700° F. to an outlet of 1100° F.

The hot inert gas circulates through two waste-heat boilers from which are generated up to 120,000 pounds per hour of 450 pounds steam and out of which the 700° F. flue gas goes to the suction of two identical 3000-horsepower circulating blowers operating in parallel. The blowers handle a total of 320,000,000 feet of gas per day and compress same from 160 to 180 pounds. The compressed gas returns to the three reactors on regeneration, thus completing the cycle. Make inert gas at 900° F. and 150 psig is used to operate a 3000-horsepower inert-gas turbine which in turn drives one of the inert-gas blowers. The 450-pound steam production is used to operate a 3000-horsepower steam turbine in turn drives the other 3000-horsepower blower. Steam leaves this turbine at 150 pounds and is reused to drive the steam-driven air compressors operating at 26 inches Hg vacuum back pressure.

Upon completion of the catalyst regeneration in any one reactor, hot flue gas from one of the other reactors on regeneration flows up-flow through the regenerated reactor, reheating the catalyst bed from about 700° to 900° F. This is called the reheat step,

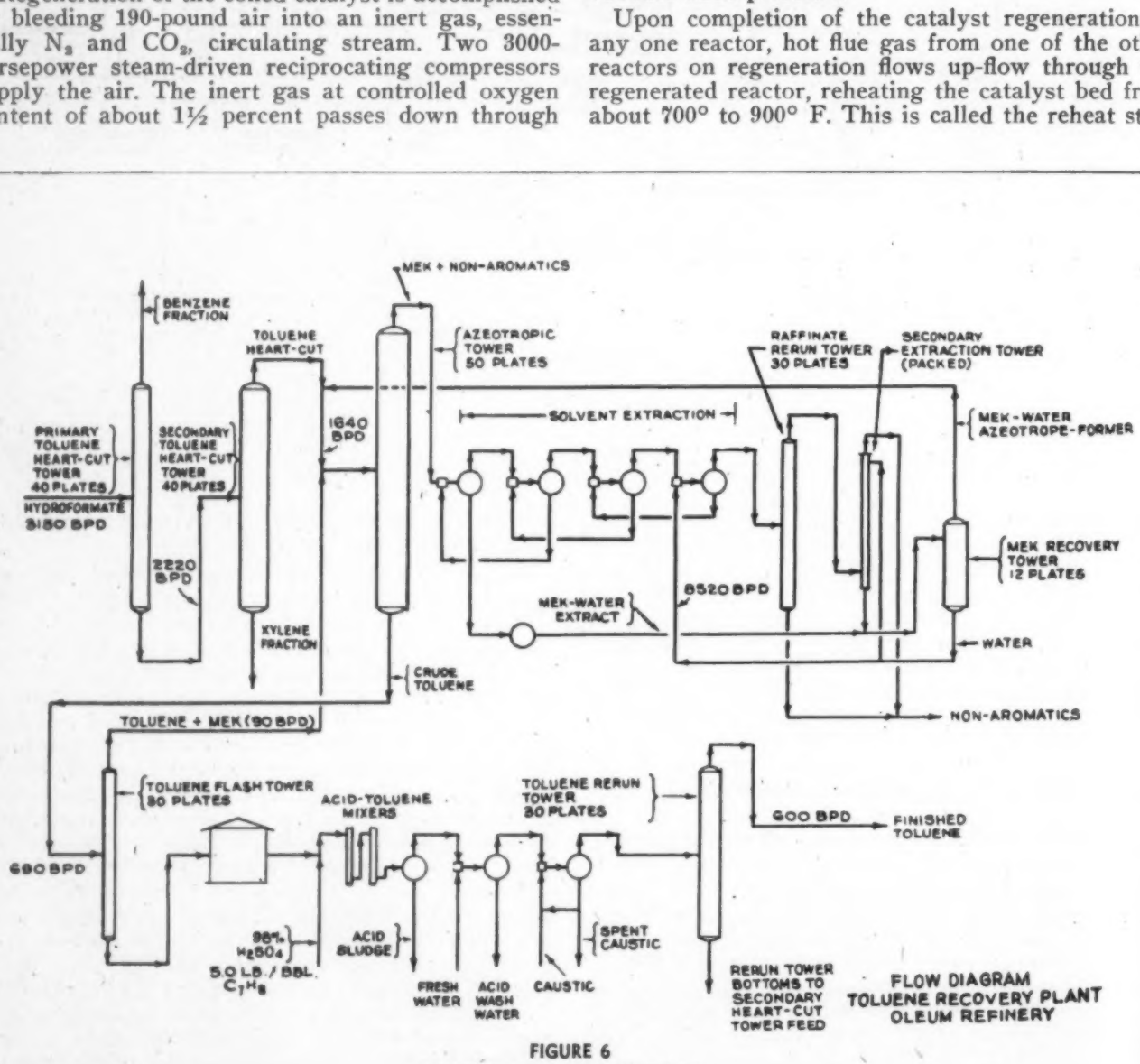

FIGURE 6
Toluene-recovery plant flow sheet.

and upon its completion the reactor is depressured to atmospheric pressure and the inert gas removed by purging with wet-gas production. During the purge period the hydrogen in the wet gas reduces the molybdenum from the trioxide MoO_3 to the dioxide MoO_2. The water formed during the reduction is swept out of the reactor. If the purge were conducted at 150 pounds instead of atmospheric pressure, the water would remain on the catalyst and lower its activity. Upon completion of the hydrocarbon purge the reactor is repressured back to 150 pounds reaction pressure and is then ready to go back on reaction.

The above operations constitute a cycle with an elapsed time of six hours. To synchronize the cycle an automatic cycle controller is employed. This controller sends out impulses to electrical relays which in turn actuate electric motors, which in turn operate a total of 52 gate valves. What would otherwise be a batch system is made continuous by means of multiple reactors and the automatic electrical control system.

Toluene Recovery and Purification

Referring to Figure 6, the two-pass hydroformate containing about 38 percent toluene now goes to the toluene-recovery plant. Prior to the azeotropic distillation step, the hydroformate is heart cut to form as narrow a boiling range feed stock as is possible in order to reduce the methyl ethyl ketone-water azeotrope-former requirements. This is accomplished by simple fractional distillation in two 40-plate towers, the overhead from the first being a pre-toluene or benzene fraction, from the second the toluene heart cut, and from the bottom of the second a post-toluene or xylene fraction. The toluene heart cut containing about 65 percent toluene is fed into the azeotropic tower along with the methyl ethyl ketone-water azeotrope-former. In the azeotropic tower the MEK-water mixture loosely associates with the paraffins and naphthenes and carries same overhead. The toluene, because of its higher boiling point, proceeds down the tower from the feed tray and is removed from the bottom as crude toluene. The crude toluene goes to a toluene flash tower from which overhead goes a small cut of toluene plus MEK, and out the bottom leaves an MEK-free crude toluene. The crude toluene is treated with about 5 pounds per barrel of

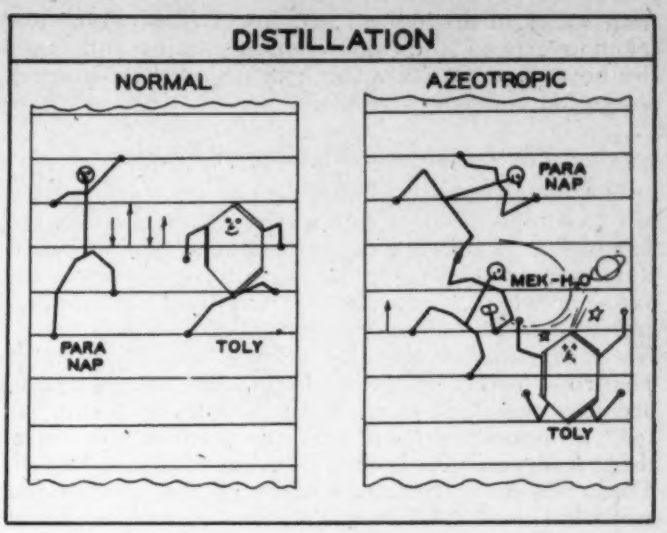

FIGURE 7
Distillation "cartoon."

98 percent sulfuric acid, settled, water washed, and caustic washed to remove very small amounts of olefins to obtain color stability. The acid-treated toluene is then redistilled to produce overhead finished nitration-grade toluene. As an alternate operation one-pass hydroformate containing 21 percent toluene is heart-cut to give an azeotropic tower feed containing 39 percent toluene. Paraffins and naphthenes are removed from this dilute charge stock without difficulty by the MEK-H_2O azeotrope-former.

The methyl ethyl ketone plus non-aromatics taken overhead in the azeotrope tower are contacted with four to six volumes of water counter-currently in four stages. The MEK is preferentially extracted by the water from the non-aromatics and separates out as a separate phase. The extract is fed into a 12-plate MEK-recovery tower to produce overhead the MEK-water azeotrope-former plus excess water, and MEK-free water out the bottom. The water cycles back to the MEK extractors. The non-aromatic raffinate from the water extraction is fed into a raffinate rerun tower from which leave at the bottom MEK-free non-aromatics and overhead a small fratcion of non-aromatics rich in MEK. This fraction is extracted

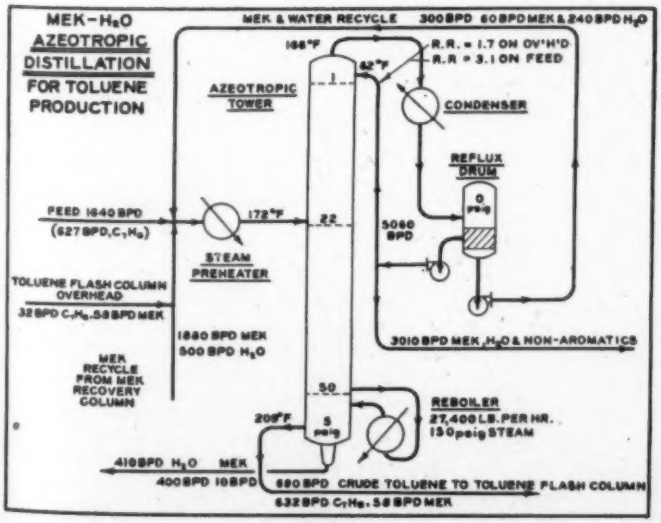

FIGURE 8
Azeotropic distillation diagrammatic tower drawing.

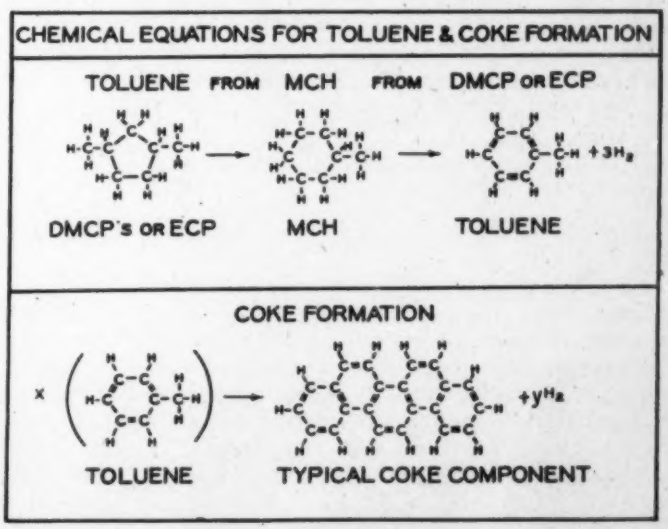

FIGURE 9
Azeotropic temperature and concentration gradients.

with water in a small packed tower from which are taken overhead additional non-aromatics and from the bottom an MEK-water extract which also goes to the MEK recovery tower.

The Azeotropic Distillation Process

The novel feature of the toluene-recovery system is the employment of azeotropic distillation for the separation of two materials of similar boiling point. Referring to Figure 7, the illustration shows what happens when a mixture of paraffins, naphthenes, and toluene is fed into a normal distillation tower. No separation occurs. By adding the MEK-water azeotrope-former along with the feed, a separation becomes possible. MEK-water azeotrope boiling at 164° F. associates itself with the paraffin and naphthene hydrocarbons boiling between 175° and 250° F. These non-aromatics are carried up the column and are taken overhead at a top temperature of about 166° F. The toluene which does not associate with the azeotrope-former leaves the bottom of the tower essentially free of non-aromatics.

Referring to Figure 8, the process details of the azeotropic distillation tower operation are given. The column itself is a conventional 50-bubble-cap-tray distillation tower and operates at a bottom pressure of 5 pounds gauge. The heart-cut toluene feed containing 627 barrels of toluene and 1017 barrels of non-aromatics is joined by about 2090 barrels a day of the MEK-water azeotrope-former (90-10) and 290 barrels per day of water recycled from the MEK-recovery tower. In addition, 300 barrels per day of water-MEK (80-20), which separates out in the column reflux drum, are recirculated back to the feed tray, plus a recycle of the overhead from the toluene flash column consisting of 32 barrels per day toluene and 58 barrels per day MEK. The ratio of azeotrope-former to non-aromatics is between 2 and 3 to 1, depending on the boiling range and type of non-aromatics present. The combined feed is preheated to 172° F. and enters the column on the twenty-second tray. A reflux rate of 5060 barrels per day corresponding to a cold total reflux to heart-cut feed ratio of 3 to 1 is employed to obtain adequate fractionation of the toluene from the non-aromatics and stripping of the non-aromatics from the toluene. Heat is put into the column by means of two parallel steam reboilers. Excess water over that required to form the azeotrope with MEK proceeds down the column and is removed as a separate stream from the bottom of the tower. This stream containing a small amount of MEK is recycled back to the MEK recovery tower.

The column is controlled by fixing all possible variables. Feed rate and reflux are on flow control. Heat input to the reboiler is varied by controlling the quantity of steam by means of a temperature controller set to maintain a predetermined reboiler-oulet temperature. This temperature is set to permit about 5 percent MEK to remain in the toluene product. At this MEK concentration complete removal of non-aromatics from the toluene is assured.

In all respects the column operates like a normal distillation tower. Figure 9 shows the azeotrope column temperature gradient and the analyses of the material on each tray of the column. From these plots we note that the toluene concentration decreases very rapidly in the upper 10 trays of the rectifying section and that the bottom 15 trays of the stripping section are required to obtain complete elimination of the non-aromatics. The MEK concentration remains essentially constant at 70 percent on the top 30 trays and then decreases in the lower twenty decks to about 5 percent in the toluene bottoms. Two liquid phases exist on the trays throughout the column, the MEK-water-hydrocarbon phase and the water-MEK phase. Sufficient agitation occurs on the trays so that the normal distillation-tray fractionation efficiencies apply.

When the charge stock contains 40 percent or more aromatics, azeotropic distilation is usually less costly than extractive distillation. An example of this somewhat similar process is the separation of toluene from non-aromatics using phenol as the extractive distillation agent. The chief difference between the two processes is that in azeotroping a majority of the agent goes overhead with the non-aromatics and in extractive distillation a majority of the agent goes out the bottom with the aromatics.

Uses of Azeotropic Distillation

The field of application of the azeotropic distillation process should greatly increase as the petroleum and chemical industries increase their production of more and more essentially pure compounds. Certainly the production of aromatics by azeotropic or extractive distillation will continue. For separating toluene and xylene from non-aromatics, MEK-H_2O azeotropic former can be employed. For separating toluene from non-aromatics methanol can also be used. Acetone can be used as the azeotropic agent for separating benzene from non-aromatics.

Acknowledgment

The author expresses his appreciation to all those giving assistance and in particular to Messrs. George Fekula and Austin McCreery.

EXPERIMENTAL DETERMINATIONS OF

Vapor-Liquid Equilibria Between Natural Gas And 95 Percent Diethylene Glycol

UP TO A PRESSURE OF 2,000 POUNDS PER SQUARE INCH

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School of Chemical Engineering, University of Oklahoma,
Norman, Oklahoma

A REVIEW of the literature failed to reveal any relevant information which might allow one to calculate with any degree of accuracy the equilibrium conditions for water and glycol in natural gas under high pressures. This investigation represents experimental studies of vapor-liquid equilibria for a 95 percent (by weight) diethylene glycol and 5 percent (by weight) water solution in contact with natural gas at pressures ranging from atmospheric to 2000 psi at a temperature of 100° F.

Theoretical Aspects

At high pressure the apparent volatility of all substances is greater than at low pressure. For example, at the extremely high pressure and temperature of impact of a high-velocity bullet, armor steel vaporizes; however, under much less severe conditions water, glycols, and hydrocarbons also tend to vaporize abnormally. Thermodynamically, the vapor pressure of a substance can be shown to increase in accordance with the equation developed by Poynting in 1881.

$$\left(\frac{\alpha P}{\alpha \pi}\right)_T = \left(\frac{V_1}{V_2}\right)$$

where $\left(\frac{\alpha P}{\alpha \pi}\right)_T$ is the differential increase in vapor pressure of a substance with respect to the total pressure at constant temperature, and $\left(\frac{V_1}{V_2}\right)$ is the ratio of molar volumes of liquid to equilibrium vapor at the same temperature.

Nomenclature

A = Ml. of bichromate solution.
B = Normality of bicromate solution.
C = Ml. of ferrous solution.
D = Normality of ferrous solution.
V = Standard cubic feet of gas.
v = Gallons of glycol solution at 60° F.
W′ = Initial weight of drying tubes.
W″ = Final weight of drying tubes.
y_1 = Mol fraction water in gas phase.
y_2 = Mol fraction of glycol in gas phase.

THIS experimental study which is related to the dehydration of natural gas by diethylene glycol was undertaken because of the need for equilibria data in the design and operation of high-pressure absorption plants.

In the laboratory a concurrent vapor-liquid contactor was used for the dynamic mixing of natural gas with a glycol-water solution of known composition. The total water and glycol-vapor content of the natural gas was determined by sorption in anhydrous magnesium perchlorate, while separately the glycol vapor was absorbed in distilled water. The water-vapor content was calculated by difference. These equilibria data are presented as a ratio of the mol fraction of the component in the vapor phase to the corresponding mol fraction in the liquid solution.

Both water and diethylene glycol equilibrium ratios exhibit minimum values at approximately 1500 psi, passing into the retrograde condensation range above this pressure. A rapid decrease in dehydration efficiency at pressures exceeding 2000 psi is indicated.

This paper was taken from a thesis submitted by George F. Russell, as partial fulfillment of the Master of Science Degree in Chemical Engineering at the University of Oklahoma, 1943. He is now with Standard Oil Company of New Jersey, Louisiana Division, Baton Rouge.

L. S. Reid, who was with Southern Natural Gas Company at the time the paper was prepared, recently returned to the University of Oklahoma as professor of Chemical engineering.

R. L. Huntington is chairman of the School of Chemical Engineering, University of Oklahoma.

Their paper is reprinted from the Transactions of the American Institute of Chemical Engineers, Vol. 41, No. 3, June 25, 1945.

Over short pressure intervals in the range of a few atmospheres, the approximate change in vapor pressure can be estimated from the known molar volumes of the liquid and vapor. As the total pressure on the system is increased, the actual equilibrium conditions cannot be predicted from the Poynting or other equations, due to forces, such as van der Waals, which affect the respective activities in the two phases.[1,2,3]

Experimental Apparatus, Procedures, and Materials

Apparatus. Figure 1 shows the concurrent, continuous flow apparatus which was used in the contacting of a

water-saturated natural gas with a diethylene glycol solution. A Rix three-stage, water-intercooled, compressor was used for compressing the gas. This compressed gas was passed through a 70° F. constant-temperature bath for saturating with water. The saturator consisted of a 3 x 18-inch high pressure tube half filled with Ottawa sand and water. The constant-temperature bath was constructed of No. 10 gage iron sheeting. A plunger-type chemical-feed pump was used for injecting the glycol solution into the system. The contactor itself was made of 50 feet of coiled 5/16-inch copper tubing. For separation of liquid and gas, a special separator was constructed with 6 baffle plates spaced 1½ inches apart, on top of

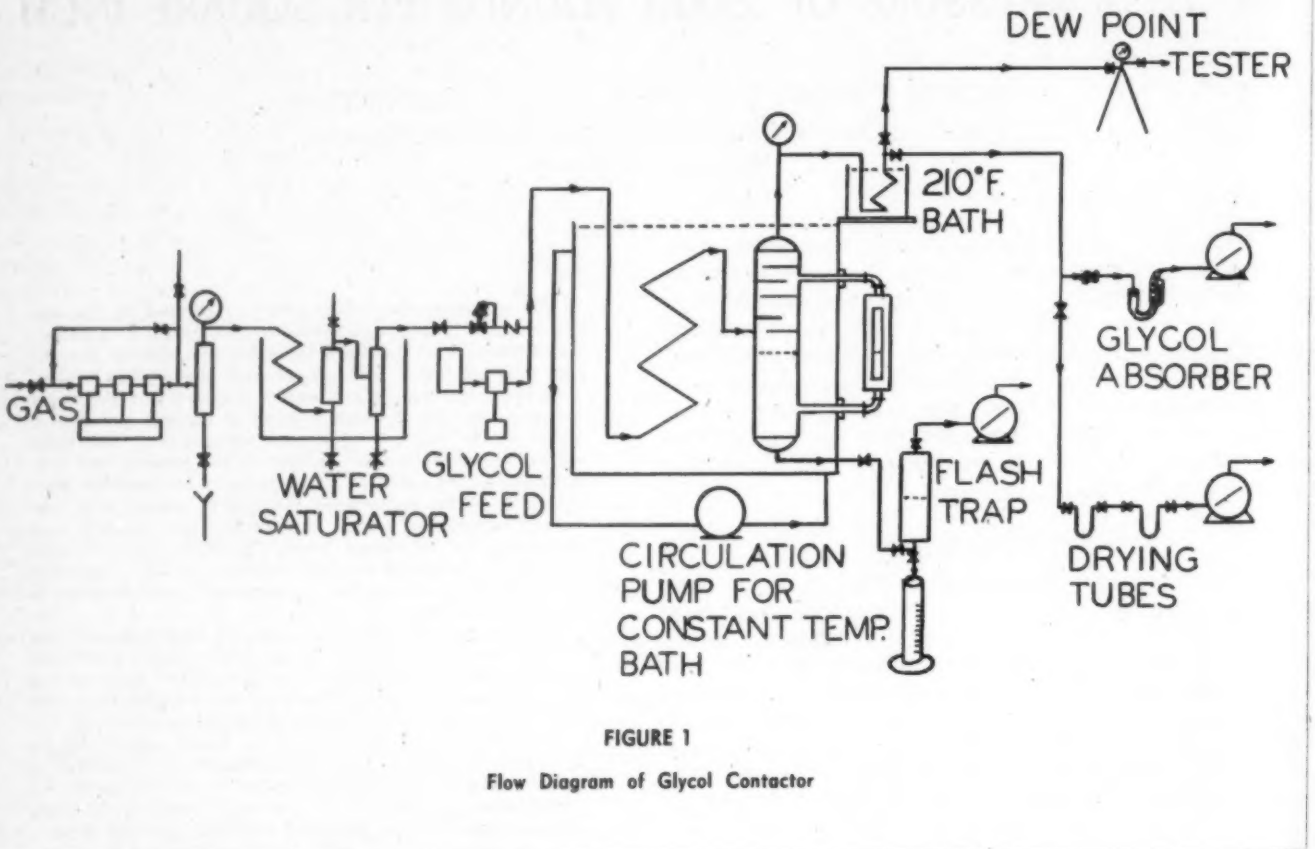

FIGURE 1

Flow Diagram of Glycol Contactor

which was a packing of approximately 3 inches of steel wool. The steel wool served as the mist extractor. Swirl preventers in the bottom section were four vertical baffles which extended ½ inch in from the walls of the separator.

The final section of apparatus involved a preheater which raised the temperature of the exit gas to 210° F. This was necessary to prevent any possible condensation or freezing due to expansion of the gas from high pressure to atmospheric. All bath temperatures were maintained at a constant value by the addition of steam or cool water as the occasion demanded.

Determination of Water Plus Glycol. Both the water and glycol vapors were removed simultaneously in anhydrous magnesium perchlorate drying tubes. Prior to tests, two tubes in series were purged with the gas to reduce hydrocarbon gas adsorption during the run. Following purging, the tubes were carefully weighed to 0.1 mg. The tubes were placed on the line in exactly the same order as when purged. It was found necessary to do this to prevent stripping of sorbed water and hydrocarbons from tubes previously used on the up-stream side. (If this is not done, the tube first used on the up-stream side will show a small loss in weight upon passing dry gas.)

The exact volume of gas passed through the tubes was measured with a wet-test meter to 0.001 of a cubic foot. All gas volumes were corrected to the standard temperature and pressure of 60° F. and 14.7 pounds per square inch absolute (dry basis). The increase in weight per standard cubic foot of gas was taken as the weight of diethylene glycol and water present in the gas. The maximum rate for substantially complete adsorption was fond by trial to be 6 standard cubic feet per hour. In order to reduce weighing and volume correction errors, approximately 18 cubic feet of gas were passed while maintaining constant conditions of operation, including room temperature. The criterion for substantially complete adsorption was that the increase in weight of the second tube should not exceed 5 percent of the increase in weight of the first tube. The dehydrating agent in the drying tubes was frequently renewed.

Separate Determination of Diethyene Glycol in Vapor. A measured volume (approximately 12 standard cubic feet) of equilibrium gas was passed through a small absorption tube packed with glass beads, and filled with approximately 25 ml. of distilled water. After having absorbed the glycol vapor, the aqueous solution was carefully washed into a 250 ml. Erlenmeyer flask, using 15 ml. of distilled water for washing. To

this was added exactly 10 ml. of 0.5 N potassium bichromate and 40 ml, of concentrated sulfuric acid.

The oxidation-reduction reaction is:

$$10\ K_2Cr_2O_7 + 3\ C_4H_{10}O_3 + 40\ H_2SO_4 = 10\ Cr_2(SO_4)_3 + 10\ K_2SO_4 + 12\ CO_2 + 55\ H_2O$$

The above reaction was allowed to reach completion by the maintenance of a temperature of 210° F. for 1 hour. The total volume of this oxidizing solution was next increased to 300 ml. by additionof more distilled water. The unused bichromate was then titrated with 0.1 N ferrous ammonium sulfate, adding orthophenanthroline indicator after the solution turned green. The end point was indicated by a color change from green to red. The difference in chemical equivalents was taken as equivalents of glycol in natural gas.

The mol fraction y_2 of glycol vapor was calculated from the formula:

$$y_2 = \frac{(AB\text{-}CD)\ (379)}{V(20)\ (454)\ (1000)}$$

Knowing the value of y_2, the mol fraction y_1 of the water vapor was then calculated by difference.

$$y_1 = \frac{(W'' - W')\ (379)}{V(18)\ (454)} - \frac{y_2(106)}{454(18)}$$

$$y_1 = \frac{0.0464(W'' - W')}{V} - 0.0130y_2$$

Determination of Dissolved Gas in Water and Glycol Solution. The equilibrium liquid glycol solution was flashed into a closed trap originally at atmospheric pressure until approximately 2 liters of solution had been collected. The pressure was slowly reduced (isothermally) to atmospheric and the volume of dissolved gas measured. The distribution coefficient in standard cubic feet per gallon of liquid was calculated.

$$K_s = \frac{V}{v} = \text{Distribution Coefficient}$$

The water content of the diethylene glycol was determined by the Hempel distillation, using a chain-packed column. Representative samples of trapped liquid were subjected to atmospheric distillation in which all liquid received below 300° F. was assumed to be water. This method was adopted since it was simple, quick and checked the composition as determined by chemical analysis within 2 percent. The chemical analysis (assuming all the glycol was diethylene) averaged 2 percent more water than the distillation method. All specific gravity determinations were made by a heavy liquids hydrometer.

Materials. The natural gas used throughout the investigation was obtained from the Oklahoma Natural Gas Company mains. Its composition was determined by means of low-temperature fractional analysis and the Orsat apparatus. (Table 1.)

The diethylene glycol was of the commercial grade as sold by Carbide and Carbon Chemicals Corporation. This glycol was blended with distilled water to the desired concentration of 95 percent by weight of diethylene glycol and 5 percent by weight of water.

TABLE 1
Analysis of Natural Gas

COMPONENT	Vol. or Mol. Percent
Carbon Dioxide	0.60
Nitrogen	1.00
Methane	94.36
Ethane	2.64
Propane	0.96
Butanes+	0.44
	100.00

Experimental Technique

In starting up the apparatus for each run it was necessary to increase the system pressure slowly to prevent the condensation of water vapor from the saturator in the upper section of the separator and preheater. Gas circulation was maintained during this pressuring-up period at approximately 10 cubic feet per hour to allow an escape for gas of higher water content. After the desired test pressure was attained, the apparatus was allowed to operate for a period of 45 minutes before the sampling began. The sampling period involved 3 hours of steady operation in which the system pressure, temperature, gas throughput, and glycol circulation rate (60 gallons per 1000 cubic feet) were held constant. The composition of the glycol feed during each run remained constant.

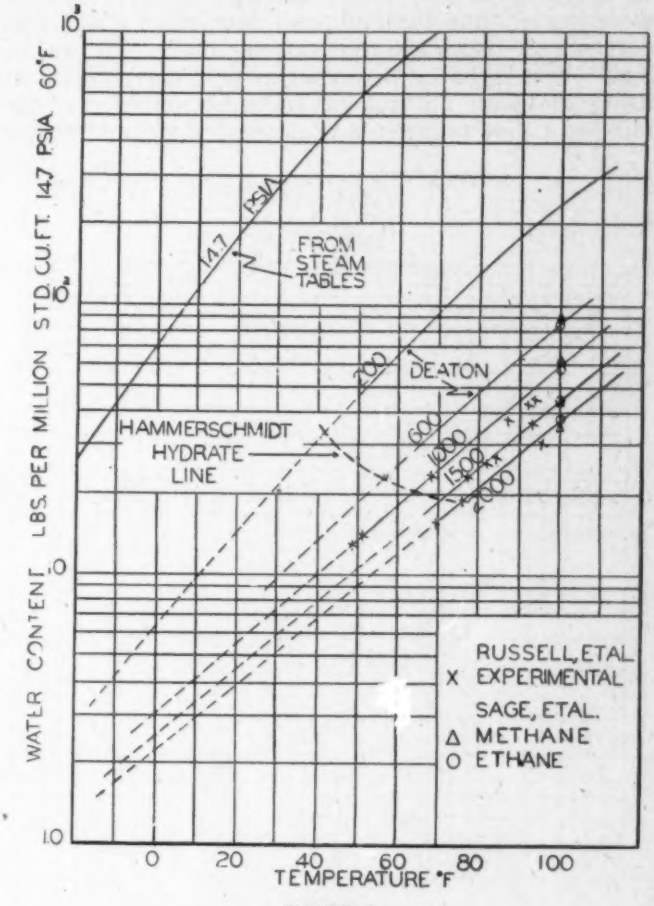

FIGURE 2

Equilibrium water vapor content of a natural gas as a function of temperature at indicated constant pressure.

It originally was planned to correlate the data with dew-point determinations, but this was found to be impractical because of inability to obtain consistent results with the dew-point apparatus. Upon cooling the dew-point mirror slowly at high pressure the customary cloudy dew point did not appear, even at temperatures as low as —30° F. It was quite apparent, however, that some kind of a dew point had been reached since liquid dripped from the mirror within the dew-point cell. On the other hand, by rapid cooling, it was possible to get a cloudy spot to appear in

TABLE 2

Diethylene Glycol Equilibrium Constants in 95% Diethylene Glycol Solution at 100° F.

Run No.	System Pressure	K*
72	0	93.0×10^{-6}
65	500	4.6×10^{-6}
69	1000	3.76×10^{-6}
70	1500	3.37×10^{-6}
71	2000	4.18×10^{-6}

$$*K = \frac{\text{Mol. fraction diethylene glycol in vapor}}{\text{Mol. fraction diethylene glycol in liquid}}$$

the center of the mirror at temperatures which varied as much as 15° F. These cloudy points invariably were higher than the indicated dew point which was determined from a water-content chart (Figure 2). This chart is based on experimental determinations using the same natural gas.[4] Furthermore, after obtaining a dew point it was necessary to remove the

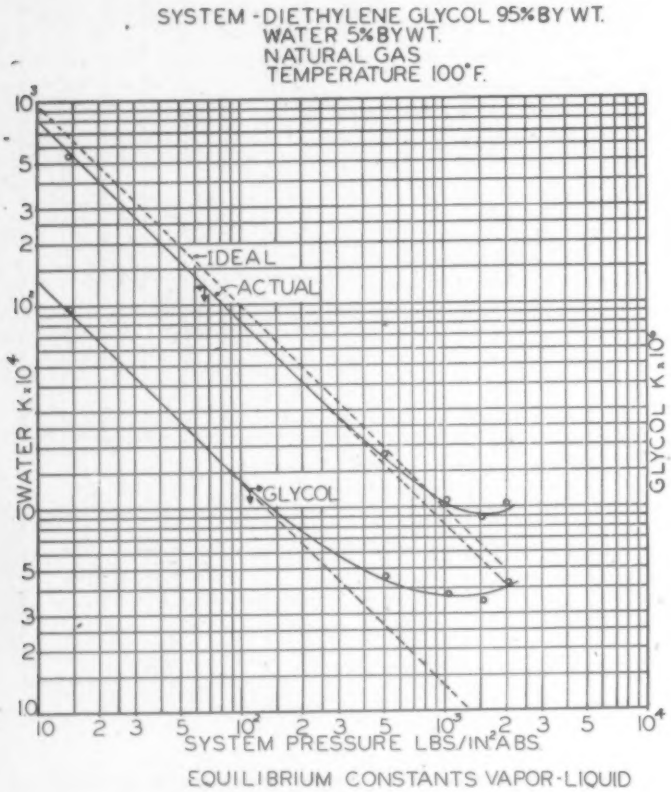

FIGURE 3

Equilibrium vapor-liquid ratios for water and glycol at 100° F. for various pressures.

mirror from the apparatus and clean with alcohol before the next dew point was obtained.

Discussion of Results

If the logarithm of equilibrium ratios shown in Tables 2 and 4 are plotted against the logarithm of the absolute pressure at constant temperature, a chart such as Figure 3 results. This clearly shows the minimum glycol and water contents per unit standard volume of gas to be at approximately 1500 psi.

To obtain water or glycol contents of the natural gas at other temperatures in the neighborhood of 100° F., use is made of the Van't Hoff Isochore.

$$\ln K = -\frac{\Delta H}{RT} + \text{constant}$$

$$\ln K \cong C(T) + \text{constant}$$

It is to be understood that this is only an approxi-

TABLE 3

Solubility of Natural Gas in a 95 Percent Diethylene Glycol Solution at 100° F.

Run No.	System Pressure Lbs./Sq. In. Gage	Std. Cu. Ft.*/Gallon
11	200	0.191
14	200	0.166
44	700	0.481
47	700	0.459
54	1000	0.708
55	1500	0.968
57	2000	1.20

* 60° F. and 14.7 lbs./sq. in. abs.

TABLE 4

Water Equilibrium Constants in 95 Percent by Weight Diethylene Glycol Solution at 100° F.

Run No.	System Pressure Lbs./Sq In. Gage	K*
2	100	59.1×10^{-4}
4	100	59.3×10^{-4}
12	200	43.2×10^{-4}
21	400	21.2×10^{-4}
25	400	22.1×10^{-4}
26	400	20.2×10^{-4}
27	400	20.7×10^{-4}
29	500	19.3×10^{-4}
30	500	18.1×10^{-4}
31	500	19.5×10^{-4}
32	500	18.7×10^{-4}
35	500	18.9×10^{-4}
38	600	14.9×10^{-4}
40	600	15.8×10^{-4}
41	600	15.0×10^{-4}
43	700	14.1×10^{-4}
51	800	11.7×10^{-4}
54	1000	10.7×10^{-4}
55	1500	9.2×10^{-4}
56	2000	12.7×10^{-4}
57	2000	10.4×10^{-4}
58	1500	8.9×10^{-4}
59	0	540.0×10^{-4}

$$K^* \text{ (Water)} = \frac{\text{Mol. fraction in vapor}}{\text{Mol. fraction in liquid}}$$

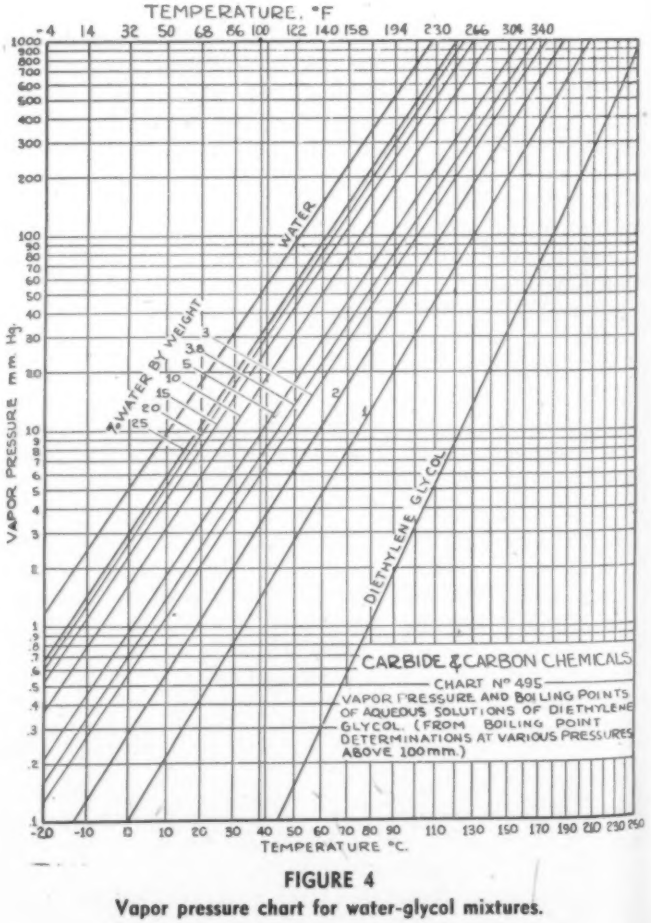
TEMPERATURE, °F
VAPOR PRESSURE, mm Hg
WATER
% WATER BY WEIGHT
DIETHYLENE GLYCOL
TEMPERATURE °C.
CARBIDE & CARBON CHEMICALS
CHART Nº 495
VAPOR PRESSURE AND BOILING POINTS OF AQUEOUS SOLUTIONS OF DIETHYLENE GLYCOL. (FROM BOILING POINT DETERMINATIONS AT VARIOUS PRESSURES ABOVE 100mm.)

FIGURE 4

Vapor pressure chart for water-glycol mixtures.

mation. By plotting the equilibrium ratio versus temperature on semi-log paper, a straight line results. From known vapor pressure data (Figure 4) the slope of these lines can be established at low pressure. Through the experimental 100° F. points a straight line is drawn parallel to the low-pressure

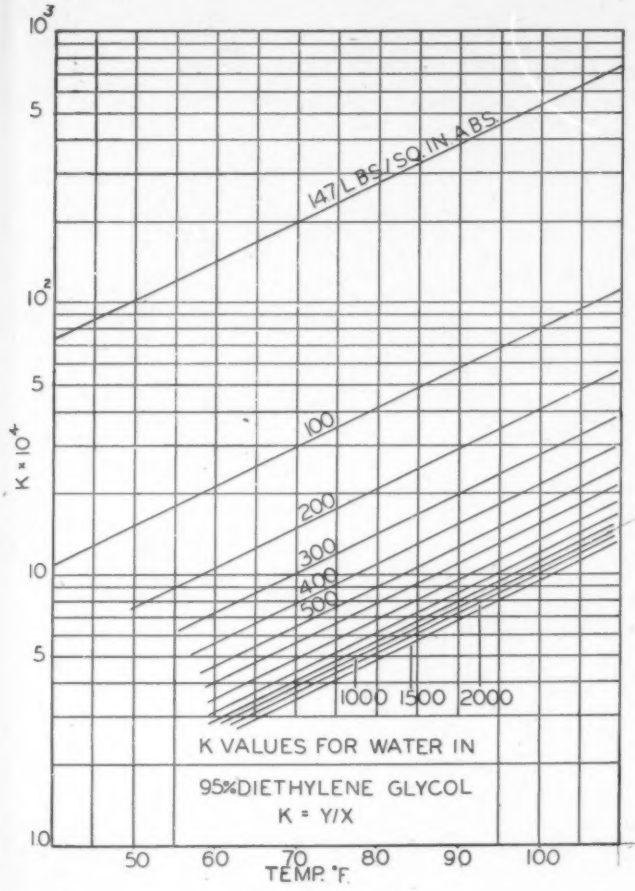

FIGURE 5

Equilibrium vapor-liquid rates for water between natural gas and glycol solution.

isobar. Figure 5 gives the results of such a plot from which the equilibrium water-vapor contents at various pressures and temperatures can be estimated. A plot of equilibrium volatility ratios for diethylene glycol can be prepared in the same manner.

Figure 6 is a graphical comparison of the equilibrium water-vapor contents of the natural gas in contact with pure water and with 95 percent diethylene glycol solution. It is of interest to note a minimum value is obtained with the 95 percent solution while the value for pure water continues to decrease. The dotted line represents the estimated trend with increased pressure.

Foaming Tendencies

In the course of the investigation observations were made of the foaming tendencies of the glycol solution upon reduction of pressure to atmospheric. Qualitatively, the tendency to foam was greater at lower temperatures and higher pressures. For example, when working at a system temperature of 100° F., visual observation of the glycol upon flashing into a glass graduate showed a much lower frothing tendency than if the system were operated at room temperature (72° F.) and the same pressure. Foaming was particularly noticeable when suddenly reducing the pressure, or flashing the liquid solution, for

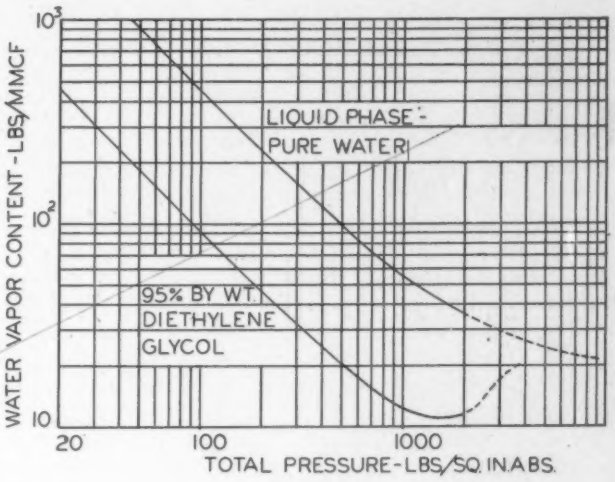

FIGURE 6

Comparison of equilibrium water vapor content if a natural gas at 100° F. for pure water and 95-percent diethylene glycol at various pressures.

determination of the gas distribution coefficient, and was especially troublesome at 1500 and 2000 psi. Too rapid a reduction in pressure caused glycol to froth out of the trap and into the wet-test meter. (This priming was detected by placing a short piece of glass tubing in a rubber hose connection to the meter.) The glycol foam was fine and creamy in appearance and had the stability of shaving lather, requiring up to 10 minutes to break.

Acknowledgment

The authors wish to express their appreciation to the Southern Natural Gas Company and the American Gas Association for their financial support of this project. Much credit is to be given to the undergraduate and graduate students who assisted in the construction and operation of the equipment.

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Modified Aniline-Point Apparatus for Dark Oils

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THE ASTM method for the determination of aniline point is not applicable to oils darker than No. 8 ASTM color[1]. It is not possible to dilute the dark oil with a clear hydrocarbon and calculate the true aniline point of the dark oil since there appear to be no simple relationship between mixed aniline point and true aniline point[2,5,9]. To detect the appearance or disappearance of a second liquid phase by the change in transparency to infrared radiation[8,10], or viscosity[4] requires specialized apparatus not readily obtained in many oil laboratories. The direct visual determination of the point at which the two phases are completely miscible is possible in a layer of oil so thin as to be transparent with the proper illumination. Such a thin layer may be produced in a properly shaped apparatus[11], or a simple aniline point apparatus with a ring stirrer may be operated so as to splash a thin film of oil up on the container wall[6], but since the wall must be at a different temperature from that of the bulk of the mixture as long as the temperature is changing, the reproducibility of the method is poor when the apparatus is operated in the usual manner[7]. The direct measurement of the temperature of such a film has been done by means of a thermocouple[4], it is however possible to obtain reproducible results with a simple aniline-point apparatus by operating it so that only small temperature gradients exists through the apparatus when making the observation, but such a procedure is necessarily very slow.

The apparatus shown in Figure 1 makes it possible to determine the aniline-point of a dark oil more quickly. It consists of an aniline-point apparatus with a ring stirrer displacing such a volume that the level of the oil-aniline mixture drops several millimeters when the stirrer is withdrawn from the liquid. The point on the tube wall where the film is observed is thus in contact with the bulk of the liquid except for a brief moment of observation. A shield is provided to decrease the heat transfer between the wall of the aniline-point tube and the surroundings at the point where the film is being observed. This shield also makes it easier to observe the appearance of the film.

Apparatus

The apparatus consists of a test tube 25 mm in diameter and 150 mm long, a ring stirrer made from 5 mm glass rod, a loosely fitted ASTM aniline-point thermometer, a shield made from a thin sheet of tin plate, the inside of the shield being insulated from the test tube by a layer of heavy paper. The apparatus is provided with a regular ASTM air jacket and a heating bath.

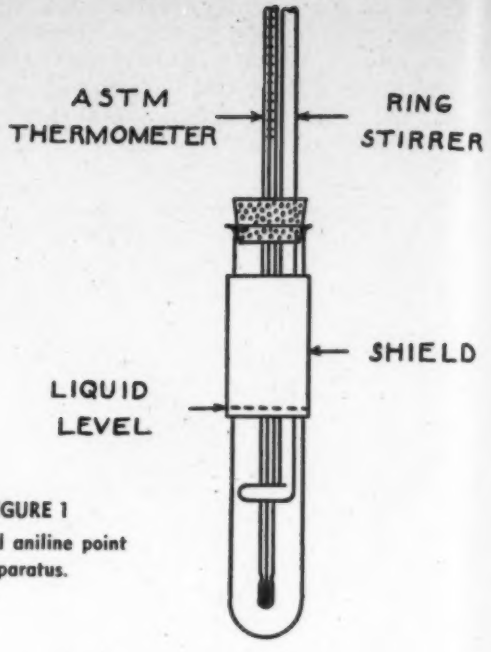

FIGURE 1
Modified aniline point apparatus.

Procedure

Ten ml. of aniline and 10 ml. of the oil are placed in the test tube. The approximate aniline-point is first determined by heating the mixture over a burner, stirring vigorously, at suitable intervals stopping the stirring and examining the mixture for disappearance of turbidity by pressing the thermometer into an inclined position so that the tip of the bulb touches the wall of the test tube, the disappearance of the second phase being observed in the thin layer between the thermometer bulb and the test tube wall by the light reflected from the mercury in the bulb. When the approximate aniline point has been determined a bath of the proper temperature is prepared so that the rate of heating does not exceed 0.2° C. per minute. The apparatus is placed in the bath, the shield adjusted with the lower edge just below the liquid level, and the mixture is stirred well. When the temperature approaches the aniline-point the stirrer is withdrawn as the temperature read on the thermometer reaches each 0.1° C. mark, and the surface of the oil-aniline mixture struck a sharp blow with the stirrer so as to splash a film of liquid on the wall. When the film has become clear, as observed in a strong light placed behind the apparatus, the temperature is noted and the mixture is cooled at a rate of 0.2° C. per minute observing the film at every 0.1° C. mark until turbidity reappears, again noting the temperature. If the two temperatures are not within 0.1° C. of each other the test is repeated, using lower rates of heating or cooling until such a check is obtained.

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Maintenance of Mercury Type Orifice Meters

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A DEFINITE program of meter maintenance is necessary to any company making use of orifice meter records. Both to insure the accuracy of those records and to protect the capital investment in the instruments themselves.

The stringency of the program will hinge upon the value placed upon that accuracy of record. The usual criterion will be the economics of the measurement, however, the element of public confidence in the company's practice, may also enter as a factor for maintaining a high standard of accuracy and the good well-kept appearance of the meter.

Since the aforementioned values will vary greatly between the various measurement set-ups, we can only generalize on the establishment of policy with regard to frequency and care in the servicing of meters, and leave the formulation of policy up to the department doing the work.

Some of the factors to be considered in establishing a measurement program are:

1. The value of the product passing through the meter.
2. The severity of the service as to heading conditions, purity of material being measured, etc.
3. The severity of the external conditions such as weather, humidity, fumes, spray, etc.
4. The value one places upon the public relations effect of good appearance and accurate measurement.

Each company will undoubtedly have meters falling under various degrees of importance in light of the aforementioned factors and will develop a program providing frequent testing and calibration of certain key meters and perhaps only periodic checking of others, with others perhaps so relatively unimportant as to demand service only when obvious error exists, as evidenced by other check meters or the like.

A good system of meter records is an essential to planned maintenance. There are a number of such systems in use and are subject to personal preference. Notes should always be made upon the chart at the time of making any repairs, adjustments or changes and should be signed by the party who makes them.

Some keep meter notes in conjunction with the coefficient records, others have separate records for each meter on an individual card. The author favors a card for each meter bearing such information as: gauge serial number, differential range, pressure range, case type, location, type of spring, type of repairs and adjustments, accompanied by the initial of the party making them and the date on which they were made.

The foregoing program will be designed to serve as overall protection to the metering system. However the possibility exists that a mishap might befall a meter shortly following the routine servicing of it and the attendant error might exist until the next scheduled service period unless some method of detection be used.

There are two common methods of detecting errors in measurement.

1. One is through the cross check of recorded volumes by comparing master meter readings, etc.
2. The other, usually the quicker and most practical method, is that of careful chart censoring. That is looking over the charts carefully as they come in from the meters.

A skilled person can quite successfully diagnose most meter trouble by comparing the normal record with the record following a mishap to the meter.

We shall list some of the more common examples.

1. Differential marks below zero continuously.	1. Usually denotes low mercury level.
2. Differential pen marks above chart range.	2. Larger plate indicated or the meter is filled with condensate.
3. No change is shown in differential when the static shows definite change.	3. Meter is binding due to friction or emulsified mercury.
4. Differential returns to a lower average, following a period exceeding the meter range.	4. Mercury lost, needs replacement.
5. Climbing or falling non-pulsating differential record, following a normal record.	5. Taplines fouled, generally due to freezing or hydrates forming.
6. Either static or differential pens apparently gain or lose time in moving over chart range.	6. Pens out of adjustment as to length.

There are a few common variations in chart records which are sometimes misinterpreted, such as:

1. A depression of differential reading to the extent of about 2/10 of an inch water differential per 500 pounds pressure.
2. A variation of meter zero to the extent of about ⅓ of one percent of maximum range of differential per 50° temperature variation.
3. A variation of about 1 percent in pressure spring reading per 50° temperature change.

In considering the work to be done in adjusting and repairing meters consideration should be given the tools to be used in doing such work. Individual preference will govern their selection to some degree, but the tool kit should be complete, including replacement parts.

In this discussion of meter maintenance, we shall consider maintenance service as applying to the following elements of a meter:

1. The differential recording element.
2. The static recording element.
3. The time recording element.
4. The meter manifold and taplines.
5. The external parts of the meter case, etc.

A statement of the ideal state of adjustment of a meter might embrace the following:

1. The differential pen should follow the arc of the chart

bearing lightly against the paper and should move freely up and down the scale to settle at zero after going slightly below, then above, and finally rest on the zero line, and upon checking should follow the water column exactly, throughout the range of the meter.

2. The static pen should move freely touching lightly and record 15 minutes earlier than the differential pen, and check with a test gauge throughout its range.
3. The clock should run smoothly and record the time correctly.
4. The meter manifold should be free from leaks, free from rust and condensate, valves should close securely and open easily and be so arranged as to permit the easy testing of the meter.
5. The meter case, house, etc., should be kept clean and well painted so as to portray an air of being well kept.

A series of suggested procedure sheets will follow indicating how to make the essential adjustments to an orifice meter.

To calibrate the differential element:

Equipment:

Tools.
1 50-inch water manometer.
1 Aspirator bulb and hose.
1 Meter chart of proper differential range, or conversion chart for square-root charts.

Procedure:

1. By-pass and shut in meter and open to atmospheric pressure.
2. Attach manometer and if no pressure is available attach the aspirator bulb.
3. Place the inches of water chart on the meter.
4. Check the mercury level and adjust with ¼-inch sub-zero adding or removing mercury if necessary.
5. Check chart at 0 then run out to maximum range of meter.
6. If pen reads more than the manometer remove the meter cover and lengthen the linkage, or if it reads less than the manometer shorten the linkage. Rerun and adjust until it checks, then check at three or four points going up and coming down and if there is any lag check all points and remove friction by lubricating or polishing the parts.
7. Enter note on chart concerning findings and the work done and sign.
8. Return meter to operating service.

To calibrate the static element:

Equipment:

Tools.
Suitable range test gauge (or dead-weight tester).
Meter chart of proper pressure range or proper conversion table for square-root charts.

Procedure:

1. By-pass and shut in the meters and open to atmospheric pressure.
2. Check differential pen to arc, then set static pen 15 minutes faster.
3. Oil all bearings and check all points of friction on static element linkage and adjust pen pressure so as to float free when the face plate is depressed ⅛-inch by pressing in on the face plate and chart with the thumb.
4. Connect test gauge and check pen reading at zero and at maximum range.
5. If pen reads less than gauge, shorten the linkage. If more lengthen the linkage. Readjust it to zero and repeat until it checks.
6. Increase the pressure, check at three or four points up and down the scale, if there is any drag, eliminate it. Check particularly at the working range.

To service the meter clock:

Equipment:

Tools.
Clock oil.
Cleaning brush and toothbrush.
Cleaning solvent.

Procedure:

1. If clock is very dirty, disassemble and scrub parts in solvent, using a fairly stiff brush, or paint brush.
2. Re-bush worn bearings by drilling out old bearing and replacing with bushing stock, then ream the bearing to fit the shaft.
3. Replace broken or worn parts.
4. Reassemble and center the balance wheel swing by adjusting the length of hairspring.
5. Adjust the verge and hatchet gear to provide an even, strong swing.
6. Oil the bearings and hatchet gear teeth.
7. Adjust to time by regulating the time lever which snubs the hairspring.

To service the meter manifold:

Equipment:

Tools.
Valve stem packing.
Auto distributor grease or equivalent.
Soapsuds and brush.

Procedure:

1. Disconnect header from meter and blow taplines to remove foreign matter. If either high or low side seems obstructed, break down fittings and probe out foreign matter.
2. Remove bonnet and stem from valves, screw stem on through the bonnet. Grease threads of stem heavily with distributor grease or equivalent.
3. Repack packing gland with suitable graphite-impregnated packing smeared with grease. Reassemble.
4. If header is very rusty, treat as the rest of the meter, by sandblasting and repainting.
5. Reassemble header and check for leaks by means of soapsuds.

To completely refinish meters:

Equipment:

Tools.
Suitable paint and brushes or air gun.
Sandblast service.

Procedure:

1. Completely disassemble meter.
2. Have meter and parts carefully sandblasted.
3. Paint all castings and case with two coats of zinc chromate primer. Paint inside chambers and floats with a dull-finish oil primer.
4. Paint with one coat of finish coat, enamel or the like.
5. Reassemble meter replacing worn parts.
6. Calibrate meter.
7. Apply overall finish coat.

Much maintenance work may be eliminated by proper choice of materials in original installations, such as:

1. Large opening stopcocks at orifice connections.
2. Large opening taplines with ample slope for drainage.
3. Use of plastic or copper tubing.
4. Use of stainless steel valves.
5. Arrange for top openings for taps on the meter run, eliminate moisture entrance to taplines and to insure proper drainage.

Random Shop Notes

When repacking valves, pull bonnet and grease the rising threads.

Make ink from glycerine and color dye to eliminate acid eating of pen by the average commercial ink.

Use colloidal graphite for lubrication of differential bearings.

Differential shaft packing, use graphite string package and Lubriseal and cardboard washers.

Parkerize inside of meter to minimize corrosion.

To change degree of choke in choke bushings cut them off and vary degree of choke by their length.

To remove old style mercury drain screws, tap sharply with two hammers from opposite sides. If the screw head is broken file away part of the stock around and tighten hand vise on the stub and remove.

Leave 1/32-inch end play to differential shafts, to insure free operation.

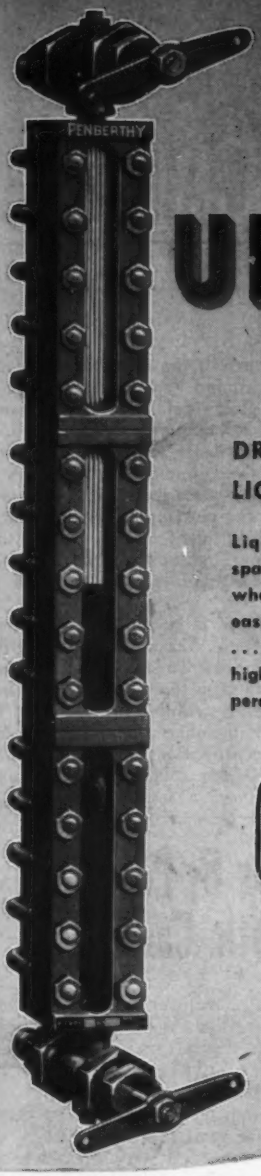
Lapping-in differential bearings insures friction-free operation. Particularly on high pressures.

To level meters, do so on the 2-inch vertical riser, rather than on the meter itself.

Lap the seats of check valves and run in ¼-inch tap to insure proper depth spacing of check valves in the casting.

Check differential shafts for straightness by rolling on a piece of plate glass.

QUALITY UNCOMPROMISED



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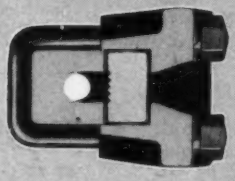
Liquid shows black—empty space shows white. Preferred wherever liquid level must be easily and positively visible . . . and when liquids are under high pressure or at high temperature.



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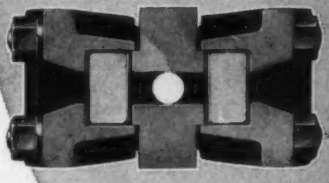

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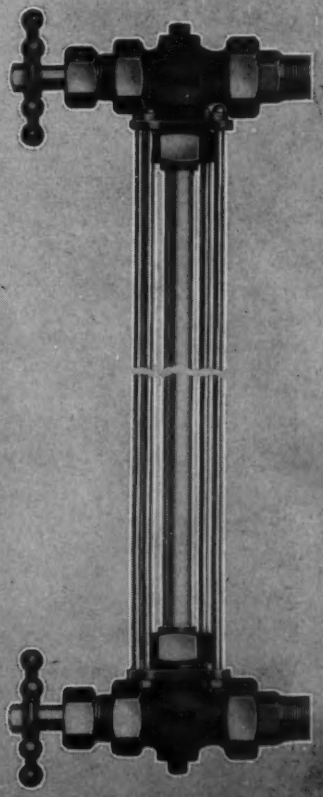
Water shows black—steam shows white. U-bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler.



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Made of Chromium-molybdenum alloy temperature-resisting steel, extra heavy throughout. Stainless steel trimmed. Tubular glass type gages also available in various other metals suitable for practically all conditions.

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PENBERTHY PRODUCTS

OPERATION HOW TO DO IT MAINTENANCE

1. Gasoline Improved by Washing With Water in Large Vertical Vessel

GASOLINE manufactured in the refinery was sometimes charged with alkaline particles not completely removed in the conventional treating plant. The result was reflected in dirty tank bottoms and sediment in tank trucks, if extreme care was not given to loading for local shipment. Frequent washing and cleaning of storage tanks was necessary. In order to remove the source of contamination, a large tank, formerly used as a storage for natural gasoline, was installed on a concrete pad some distance from the doctor-treating plant and connected to the line to the tank farm.

To obtain the full benefit of water wash, an internal spider was constructed of three-inch pipe, using a horizontal header to which is connected six right angle branches, all being perforated with holes bored in the sides to break the gasoline into as fine a stream as practicable. The inlet nozzle being three-inch, the combined volumetric area or the small holes was calculated to be slightly under the volumetric capacity of an open three-inch line.

In practice, the water wash tank is filled approximately a fourth full of fresh water. A gauge glass on the side near the controls indicates the level. No time is set for dumping the wash water as laboratory control takes over and runs frequent tests to determine the quality of the water while in use. If at any time an alkaline reaction is found on the water sample, the treater dumps the contaminated wash and refills with fresh water.

With a settling time of about two hours, there is a quantity of gasoline in the vessel which must be vented quickly if and when the product specifications are changed. Venting is accomplished by pumping fresh water into the vessel until sampling discloses water coming from the overhead outlet line. Input water is shut off, and the bottom drain opened by cracking the drain gate so as to dispose of approximately half as much water in volume as gasoline entering the treater.

At no time since this tank has been installed has there been the least indication of sludge in vessels in the tank farm, nor has there been any indication of alkaline gasoline delivered to tank trucks. The cost of operating is only the cost of the water used.—*I. D., California.*

THE WINNER

A number of readers selected at random and asked to evaluate items printed in this department in October have indicated the award should go to Item 4—"Bleeder Prevents Pump Vapor Lock." Accordingly, a $25 Victory Bond is being sent to "E. S."

EACH month the operating personnel in the refining, cycling and natural-gasoline plants determine the winner of a War Bond, maturity volue $25.00.

Superintendents, assistant superintendents and foremen (subscribers as well as non-subscribers) become a jury to select the most practical contribution to this department on maintenance and operation. The editors rotate voting among men qualified to determine the rating.

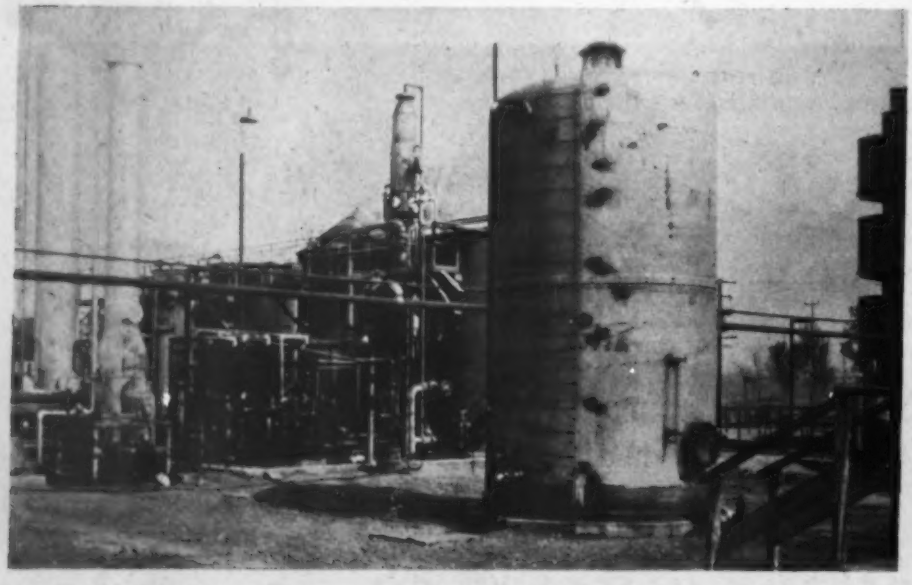
This award is in addition to payment for the article. These methods of solving plant operation and maintenance problems come from the personnel of the industry. Items provided by Petroleum Refiner staff members will not be eligible.

Send contributions to Petroleum Refiner, P. O. Box 2608, Houston 1, Texas.

2. Vapor By-Pass Stops Caustic Carry-Over

A SMALL refiner who converted the primary distillation section of the plant to produce aviation base stocks encountered a small carry-over of liquid caustic solution as the product passed through successive contacts to the pressure storage tanks. The quantity of uncondensed material was almost insignificant when compared to the volume of liquid, but this small amount of vapor caused a turbulence in the treating vessels to produce a carry-over of the liquid treating solution.

Connections were inserted in the prod-



View at left shows tank adapted to water-wash service to remove treces of alkaline solution after treating. Detail of inlet piping is shown in the picture at the left; upper pipe is for water inlet and lower is for gasoline which goes through the distribution spider.

Some refineries have found it well worth while to install traps in lines of any length, to remove moisture, which will otherwise sludge the lubricating oil . . .

Practically all refinery cleaners are air-driven . . . therefore it seems logical to start an investigation at the source of power — the compressors. Assuming them in good condition, check each air line for pressure drop . . .

Hose couplings are frequently a source of trouble which is often due to the hose becoming oil soaked at the motor coupling, allowing it to pull loose . . .

The motor must have enough air pressure to provide the necessary speed to enable cutters to *penetrate* rather than grind out the coke. However, above a certain peripheral speed cutters and fins will turn blue and lose their hardness. Thus motors and heads should be matched . . .

Another source of coupling trouble is with the nipple on the motor end of the hose coupling. If the motor is not threaded all the way on the hose nipple, the nipple may snap under heavy vibration . . .

"How much oil does a cleaner require?" This obviously depends upon the size of cleaner and type of oil . . . The only sure test should be a film of oil on the exhaust ports of the motor after it has been run . . . Oil is cheap compared to burned-out motors . . .

The greatest problem in tube cleaner work is the correct selection of cutter head . . . More heads have failed because of incorrect application than for any other reason . . .

The hose is just as important as the cleaner and should be checked often . . .

Practically all cutter heads are self-feeding. Let the cleaner feed slowly and evenly and if necessary hold it back slightly, and the head will not jump coke . . .

How to
make tube cleaners
last longer—
work faster—
clean better—
An authoritative article by L. A. Kunzler, tube cleaner specialist, reprinted from PETROLEUM REFINER and distributed by ELLIOTT COMPANY, Springfield, O.

Here's really informative data on tube cleaning

The above extracts will give you an idea of the character of this bulletin. It is rich in vital factual material gathered the hard way—through life-time experience. The bulletin is a reprint of an article from "Petroleum Refiner" by Mr. L. A. Kunzler, Sales Manager of Elliott Company's Tube Cleaner Department. It is *not* a treatise on Elliott tube cleaners, but a valuable dissertation on methods of speeding and bettering the tube cleaning job, by a veteran specialist in the business. Every maintenance engineer will want one or more copies—free at your request.

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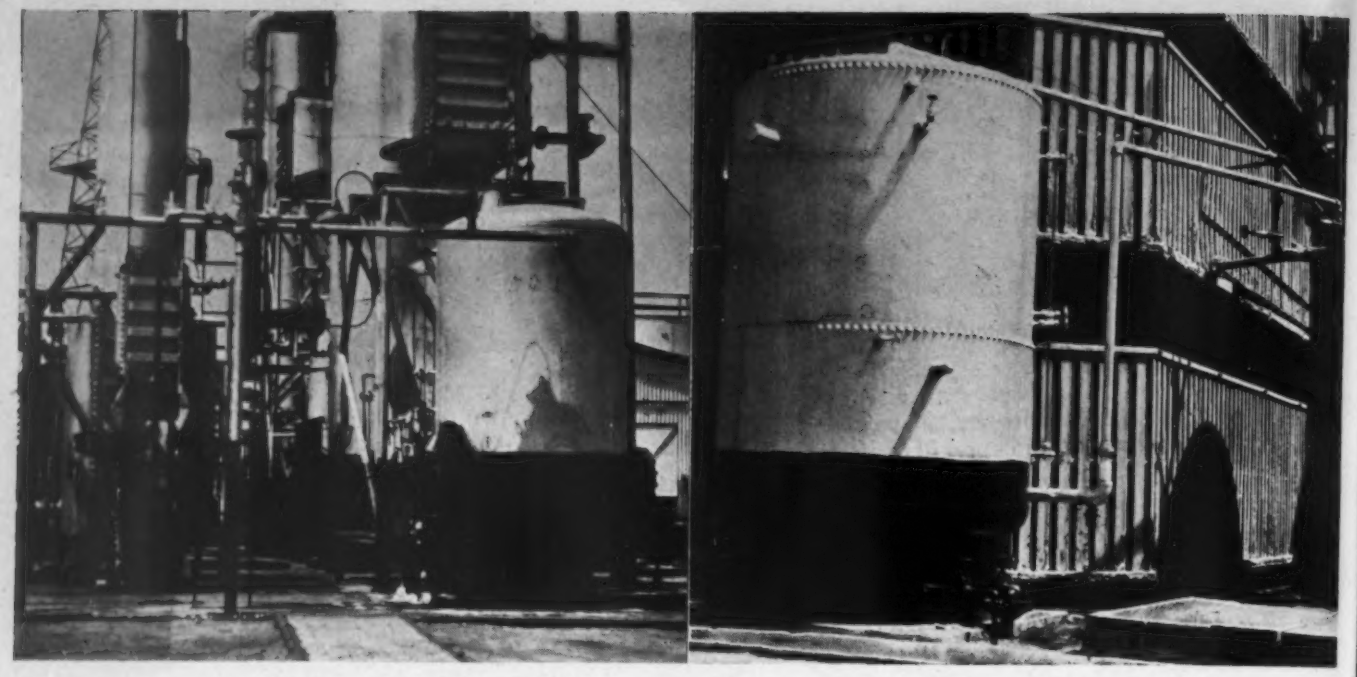
ELLIOTT—TUBE CLEANER HEADQUARTERS



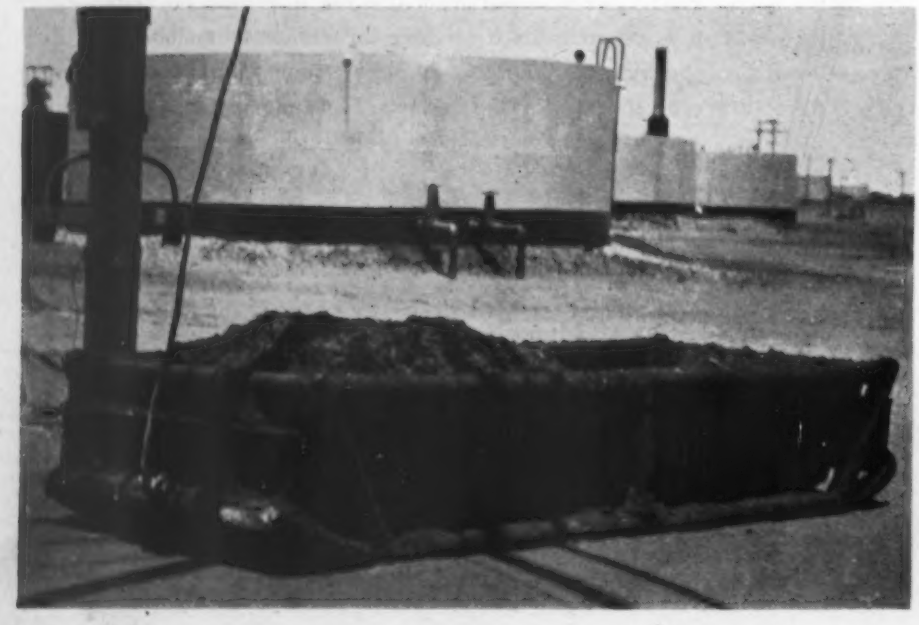
Primary caustic-wash, left, showing small copper line which bleeds some of the vapors to reduce turbulence in the chemicals. Tube connection also is shown on the secondary wash tank at left.

uct lines at the highest point between the run-down tank and the first caustic contact vessel. A similar connection was placed in the center of the top head of the treating tank and the two connected with a common copper tube, with gate valves at both connections to control or shut off passage of vapor as desired. The second contact vessel was installed near the pressure storage tanks with provisions made in the lead line from the primary contact vessel to include an elevated loop so that vapors at this point could be bled from the top of the line. Similar connections were welded into the transfer line and above the treating level of the caustic, connected also with a copper tube.

It was discovered after the installation had been made that only a small amount of vapors needed to be by-passed to reduce turbulence to a point that prevented carry-over of the treating solution. The amount of opening is determined by the temperature of the condensing water. When sufficient evaporation is obtained in the cooling tower to obtain a total condensation of distillate, the by-pass could well be closed. But, since they were designed to carry vapors, the small quantity of liquids passing through the lines in the absence of vapors caused no added difficulty in treating.—*J. C. A., California.*

3. Waste Material Sled Eliminates Shoveling

THE handling of coke, scale and other waste materials accumulating around the refinery during an overhaul usually involves a number of handlings of the material unless special provisions are made, as at one plant, for collecting and disposing of the waste.



A skid frame, welded from scrap pipe, is given a bed of reclaimed tank plate, forming a bin with a capacity of around a cubic yard of material. This sled is spotted at the site where the waste accumulates, and, being low, readily is filled by laborers with shovels—in contrast to the difficulty of transferring the waste to a high truck body.

After the sled is filled, it is towed by a truck winch line to the disposal area and the winch line then taken up on the drum until the skid is overturned, dumping the waste without requiring a second handling, as would be the case where a truck was used.

If the winch line be used with the usual gin pole, instead of trailed off the bed of the truck, the amount of towing line used determines whether the skid is to be pulled—allowing it to be spotted around equipment where fire hazards prevent the use of a truck—or whether it is to be lifted by the forward end and overturned.

Once emptied, the sled is readily righted by hoisting it to the vertical and canting it over on the runners for reuse. Being of all-welded construction, the sled can easily be hosed clean or, if the waste material be oily, it may be burned clear without injuring the unit. —*E. S., Texas*

4. Lifting Equipment Stored Outside

THE customary welded frame on which the chain hoist is suspended for removing heavy units, such as cylinder heads in a compressor plant, is bulky and takes up floor space which was not allotted to such storage, during the periods between overhauls.

By fitting the ends of the pipe forming the bases of the frame with pads of plate, one company attaches heavy

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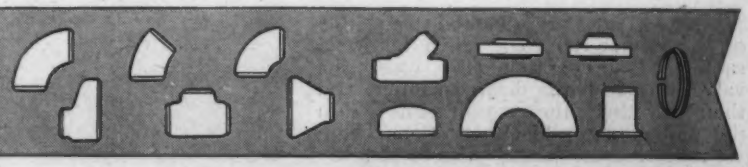
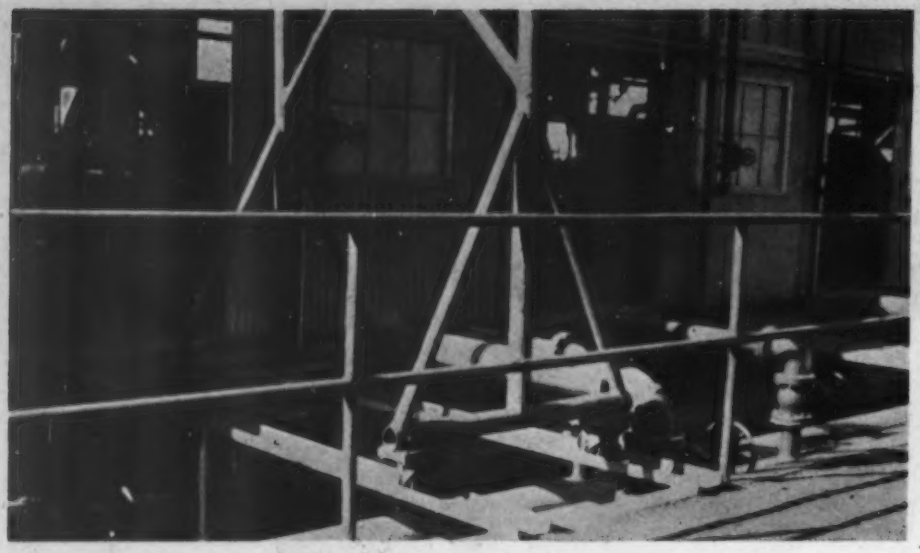


THE COMPLETE LINE OF WELDING FITTINGS AND FLANGES



Base of lifting frame, showing casters which facilitate moving it about, and rails which permit it being pushed outside and out of the way between its use on equipment.

casters so that the unit may be rolled to and away from the job, providing heavy U-shaped blocks which slip under the pads and relieve the caster of the load while the frame is supporting heavy equipment.

To permit storage of the frame outside the building, and thus retain free floor space for operating the plant, the company built a pair of rails, spaced to match the setting of the casters on the base or the frace, so that the doors could be opened, and the frame rolled out onto the pair of channel beams to find storage space over the pipe header pit.

The frame is given an occasional coat of paint to prevent rusting while in the outdoor storage, with the bearings of the casters being packed with a waterproof grease to maintain them in proper condition.—*G. O. S., Texas.*

5. Composite Hook-Up Simplifies Sampling

PRODUCT or process samples may be obtained for any 6- 24- or 48-hour operation as desired, if a sampling unit be used which will permit of calibrating the periodic additions to the composite in the sampling device.

One refinery mounts a pair of collectors, formed from orange-peel ended 6-inch pipe some 30 inches in cylinder length, with inlet fittings attached to the top and extending almost to the bottom of the unit. Sample cocks for checking the sample also are attached to the upper head, with the drop legs extending nearly to the bottom of the unit. By use of a manifold, samples may be withdrawn from any desired level within the collector.

Gauge glasses are attached to the side of the device, so that, when taking a sample, the operator may open the valves to admit the desired sample, and then may check the amount admitted on the gauge glass—his instructions being set up in inches, gauge, so as to simplify metering.

The sample enters through the extended incoming line, being discharged near the base of the cylinder so as to insure adequate turbulence to mix the new material with the liquid previously admitted, insuring a true composite at all times.

Drain fittings are welded into the base of each cylinder, to permit thorough purging of debris which may collect during operation. These fittings also allow the unit to be flushed out when a new type of product is to be collected.—*L. S. H., Louisiana.*

Coposite sampling hook-up

6. Auto Ignition Adapted For Gas Engines

AS A method of using available materials many operators are converting automobile and other distributor-type ignition systems for use on single-cylinder gas engines. The converted ignition system is applicable to either a two- or four-cycle engine.

Use is in small compressor plants or booster stations. However there is nothing involved in either design or operation to prohibit its use in general operations.

Fundamentally the method is simple in both construction and operation. Many different arrangements of the system's parts may be made with equal success in performance, and the accompanying schematic layout is intended to illustrate possible location and purpose of the parts. The system uses a storage battery with the spark regulated and timed by a converted ignition distributor geared directly to the flywheel.

Converting the Distributor

Practically any distributor can be converted for this purpose, by inserting a turning crank and gearing it to the rotor of the distributor. One method, which is commonly used, is to form a crank of ⅛-inch steel rod, as shown in the distributor and turning crank sketch. This crank is securely fastened, on suitable bearings in the distributor with a gear on the inside end to turn the rotor. The outside end of the crank is shaped as shown and fits into the slotted drive wheel which is bolted to the flywheel.

The slotted drive wheel may be constructed of ⅛-inch plate, with a slot somewhat wider than the diameter of the distributor turning crank cut part way in towards the center of the wheel. The drive wheel is either drilled and threaded, or welded, onto its drive shaft of ¼-inch rod, which is fastened to a flange on the other end and bolted to the flywheel. Dimensions, size and thickness of materials used in the turning mechanism are optional as very little strength is needed to overcome the turning friction of the distributor.

In assembling, the drive wheel is cut, slotted, attached to a flange by the shafting, and bolted to the flywheel. The distributor is converted as outlined and attached to a suitable pipe stand. The distributor and pipe stand are put in place with the distributor turning crank fitting into the slot in the drive wheel, as illustrated in the distributor and turning crank sketch. The distributor and its pipe stand are in the position shown in the schematic diagram. It is necessary that the pipe stand be plump and that the distributor, turning crank, slotted drive wheel, and flywheel be in alignment for smooth operation of the mechanism. The distributor pipe stand is then cemented firmly in place.

In connecting the system it is usual practice to use ½-inch pipe, or larger, as a conductor for the wiring to prevent loose wiring in the system. Some operators insert a flange into the distributor into which is screwed the pipe wire conductor.

The schematic layout illustrates the wiring, with the distributor being con-

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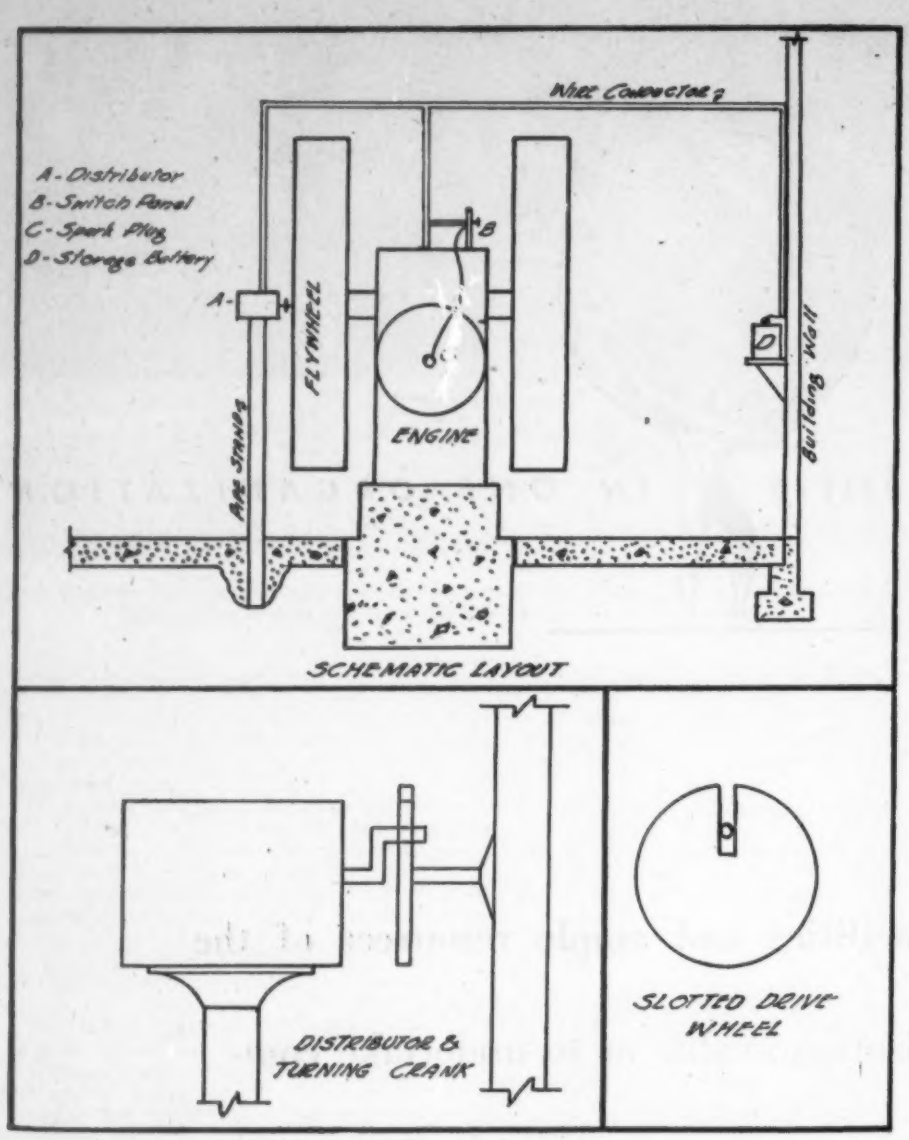


Auto ignition converted for gas engine

nected to a switch panel mounted on top of the engine and to a storage battery mounted on the wall of the building. This method allows easy inspection and replacement of any part of the system, and does not interfere with operation of the engine's moving parts or movement of personnel.

In operation the slotted drive wheel, being bolted to the flywheel, turns the distributor turning crank which turns the distributor rotor, as the engine flywheel turns. When the rotor reaches a point the spark passes to the spark plug. Timing is easily accomplished and quality of the spark depends only upon the charge of the battery, condition of the plug, and condition of the wiring. It is easily controlled by the most inexperienced operator.

Some operators have a recharging unit in the plant and a spare storage battery, one to be used while the other is being charged.

Regardless of how the system is constructed, the method of using a storage battery and a converted distributor as an ignition system for single-cylinder engines has been successful, is very economical to install and is most trouble-free in operation. If available the heavy-duty commercial distributors are desirable.

7. Cooling Section Tubes Welded

WHEN a manufacturer recently built a gasoline plant, the atmospheric cooling sections on hand were too short by half to fit into the proposed cooling tower, and new sections were not readily available. A sufficient number of the short sections were on hand and it was decided to lengthen the units by removing the tubes from all sections and brazing two at the ends to form a tube long enough that the completed section would serve the desired results in the new cooling tower.

The tubes were separated from the cast iron headers in the usual manner when replacing or changing tubes, and were then placed on a set of knife-edge supports so that, when joined, the lengthened tube would be as straight as a new one fresh from the mills. Replaced in the headers and rolled, the improvised tube bundle was ready for installation. As supports for the center of the lengthened tubes, to prevent sagging, channel iron cross members were welded to the channel iron side spacers.—*B. R. K., Texas.*

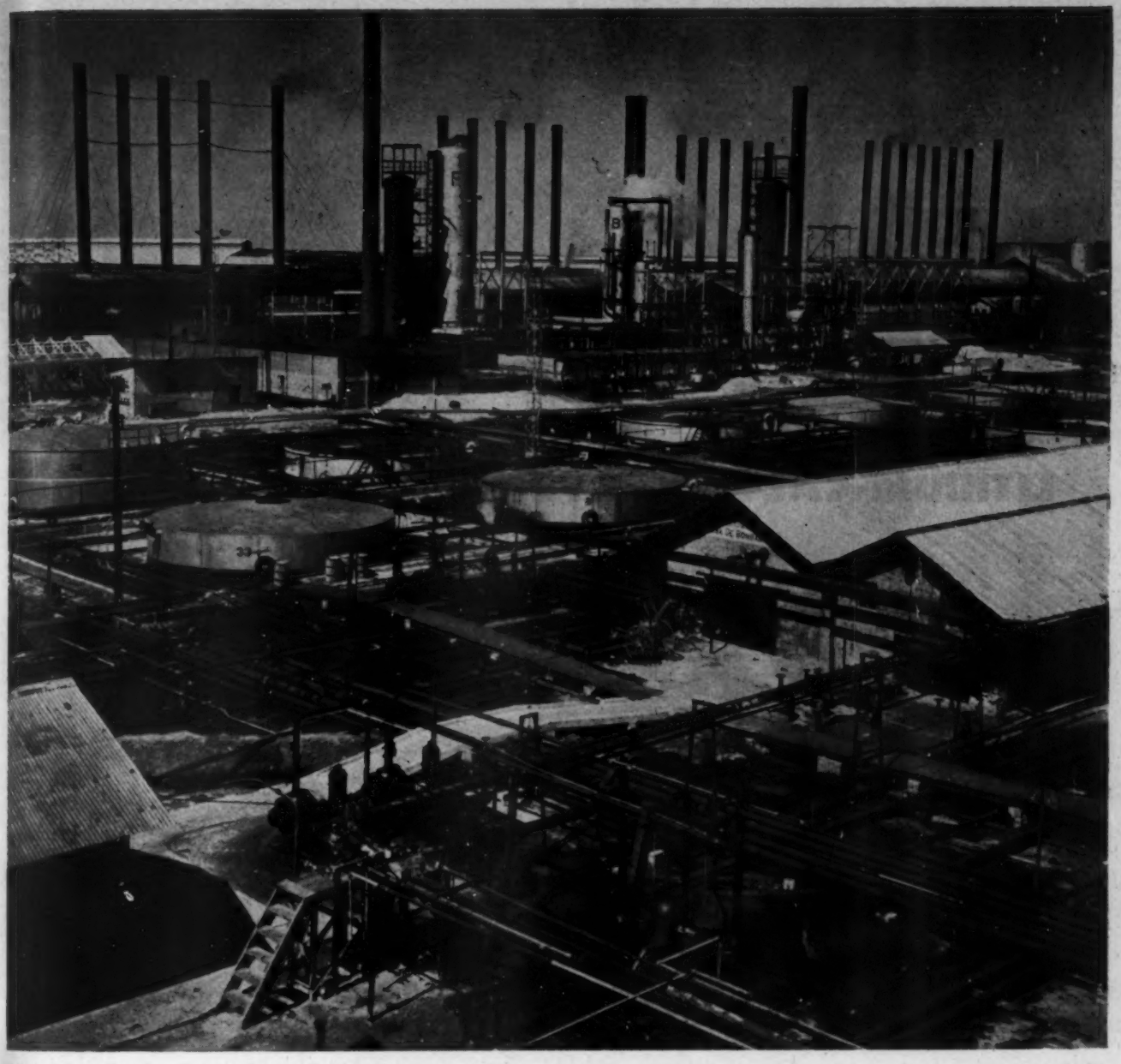
8. Vacuum Relief Valve Unloading Tool

OPERATORS at gasoline plants are familiar with unloading vacuum-relief valves, and when performing this operation with the hand, considerable pressure is necessary at times, and finger nails are frequently broken on the metal seats. Employes at Skelly Oil Company's Cunningham, Kansas, gasoline plant decided that a tool was best for this type of work and designed one which unloads the vacuum releases easily and without danger of injury.

A section of half-round iron rod was bent by heating to the shape desired, and a small, round pallet welded to the upturned end which is used to unload the valve. The tool is placed on the piping near the vacuum valves so it may be secured readily when it becomes necessary to relieve pressure on the inside of the storage tanks.

Vacuum valve tool

READERS ARE URGED TO CONTRIBUTE items to this department. Drawings or photographs are desired where practical. Payment for items accepted will be on a basis that will compensate for the time involved and in addition each contribution will be eligible to receive the bond award as outlined in the announcement on page 146. Jury awards will be announced in the second issue after publication.



Distillation units at Madero Refinery, Tampico, Mexico

Mexico Modernizing Refineries In Enlarging Oil Facilities

L. J. LOGAN

SOME important expansion of refining facilities is under way in Mexico, and more is projected under the plans of Petroleos Mexicanos, the government-operated company which was made trustee of the government's petroleum resources after expropriation of most of the oil industry in March, 1938.

The company, sometimes referred to as "Pemex", expects consumption of petroleum to increase steadily in Mexico, as it has done in the past, domestic use having risen from 66,000 barrels daily in 1938 to about 96,000 daily in 1944, and to meet the growing needs, appropriate expansion of all phases of the industry is being attempted and projected.

The expansion of refining will be in line with enlargement of distribution and transportation facilities and with a program of intensified drilling and wildcatting for new crude oil.

Already well advanced is the construction of new, modern facilities at Atzcapotzalco refinery in the suburbs of Mexico City, which will afford production of aviation gasoline and permit volume production of higher quality motor fuel. The capacity of the refinery will be increased to about 50,000 barrels daily from about half that amount. Work was started in late September on construction of a refinery at Salamanca in the state of Guanajuato, east of Guadalajara, and to the northwest of Mexico City. Planned as a 30,000-barrel daily capacity plant, it will supply the adjacent industrial and mining region and will be built partially with equipment from the Mata Redonda and Bella Vista plants in the Tampico district, which

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will be dismantled. This will leave at Tampico the two main plants, the Ciudad Madero and Arbol Grande refineries, which will adequately serve that district. Those plants are in fair condition but are in need of modernization, which Pemex will undertake henceforth. Pemex also plans to modernize the large Minatitlan refinery in the Isthmus. While the Pacific Coast of Mexico is supplied by products refined at Minatitlan and shipped by rail to Salina Cruz, it is contemplated that eventually a crude oil pipe line will be laid from the Isthmus fields to Salina Cruz and that a refinery will be built at the latter point. Already well advanced is the construction of the crude oil stabilizing and natural-gasoline plants in the Poza Rica field, which will recover around 4000 barrels of petroleum liquids daily. Those plants are intended to fit into the program of supplying the Mexico City consuming area.

The refinery construction at Mexico City and that proposed at Salamanca require important pipe line work, which is under way. At the 6 reciprocating pump stations on the 10-inch pipe line from Poza Rica to Mexico City, Pemex is installing new electrically driven centrifugal pumps, and is supplementing those stations with 3 new stations similarly equipped. These 9 centrifugal-pump installations will permit about 50,000 barrels daily throughput of crude in the existing line, compared with about 22,500 daily heretofore. The existing reciprocating pumps will be left undisturbed for use on a new pipe line to be laid partially alongside the existing line in supplying the projected refinery at Salamanca. This line will follow the present line from Poza Rica to the last of the existing pump stations near Beristain and there fork off to the west and follow highways along a fairly straight line to Salamanca.

The new facilities at the Mexico City refinery are being built with new equipment and in the most modern way. It is hoped that the refinery when completed can turn out 50,000 barrels a day of products. The new facilities include a new crude distillation plant, Dubbs cracking unit, alkylation plant, etc. The refinery heretofore was only a topping-skimming plant, and in order to provide sufficient gasoline production for the adjacent large consuming area, Pemex has supplemented pipe line runs of Poza Rica and Tampico district crudes to Mexico City by also piping in some gasoline from Tampico refineries and the limited natural gasoline production of the original small absorption gasoline plant at Poza Rica. (The pipe-line system to Mexico City extends on beyond Poza Rica to connect with the extensive system of the Tampico-Tuxpan district.)

The new facilities of Poza Rica include a crude oil stabilizing unit to drive out gas and the lighter ends, and facilities are being provided for desulphurizing the oil. For heating the crude, five updraft type heaters are being installed. In the absorption gasoline plant unit of the project there will be 7 600-horsepower and 4 300-horsepower compressors, besides which there will be 10 100-horsepower units as auxiliary facilities. The gasoline plant will be able to process 60 to 75 million feet of gas per day, and is expected to recover 3000 to 4000 barrels per day of liquids.

This new plant at Poza Rica, the pipe-line improvement, and the expansion of

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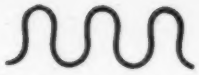

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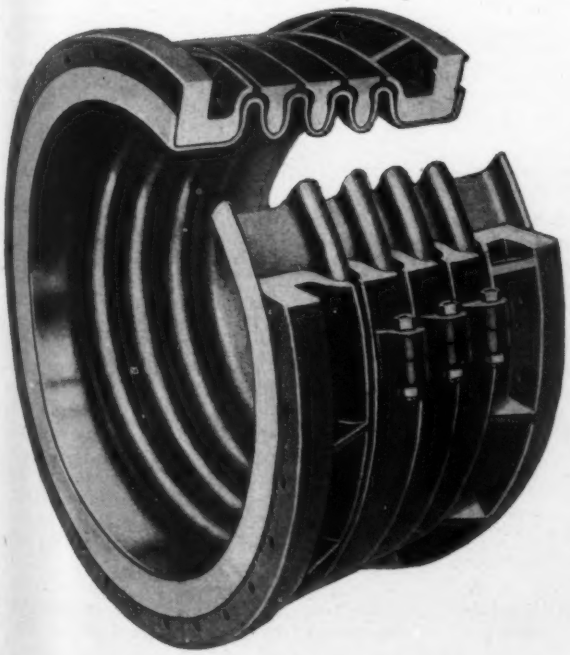

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refining capacity at Mexico City, comprise a project that has been described as an 18 to 20 million dollar undertaking, for which the Export-Import Bank of the United States government loaned over half the capital. The work was classed as a war project, which would enter into the security of the Western Hemisphere and provide a new source of aviation gasoline in that connection. All the construction work is being done by Arthur G. McKee & Company, and the United States government's interest has been looked after by the Petroleum Administration for War. Petroleos Mexicanos also made a contract with Phillips Petroleum Company under which Phillips serves as technical consultant to Pemex during the construction and as trainer of Mexican refinery engineers who will be in charge of operations when the project is completed. About 25 Mexican engineers are being trained in refineries of Phillips Petroleum Company in the United States, including those at Kansas City, Borger, and Seminole, the latter being very similar to the Mexico City project. Phillips Petroleum Company each week makes photographs and reports on progress of the refinery construction, sending them to the Mexican engineers in the United States so they can watch progress on the plants. The company will continue to furnish advice and assistance until the refinery is in smooth operation, and probably will keep several technicians at Mexico City for a considerable period after the project is completed.

Plans for Refining and Distribution in Mexico

(A statement made available by Petroleos Mexicanos and prepared under supervision of Engineer Carlos L. Corcuera y Riba, manager of the refining department.)

In view of the constant increase in the demand for petroleum derivatives in Mexico and of certain changes in the production field, and taking into consideration the future prospects in the line of transportation, a new schedule has been proposed for refining and distribution up to 1950.

For developing this project, three great refining and distribution zones are to be established: the Central Zone, the Gulf Zone, and the Pacific Coast Zone.

The Central Zone

In the new distribution system proposed, the plan is to develop the Atzcapotzalco refinery by first augmenting its capacity so that it can handle all the crude that the pipe line from Poza Rica is able to deliver after all the improvements are completed as planned and which we believe will be approximately 50,000 barrels daily. This project for Atzcapotzalco and the Poza Rica pipe line is now in process of construction and should be completed by the end of 1946.

Primary distillation plants will be installed at Atzcaptozalco, as well as secondary, disintegration or cracking, rectification, alkilization and isomerization for the production of aviation gasoline, also plants for the production of lubricating oils and paraffins, treatment units and all related services in connection with the existing plants. All this, when completed, will constitute one of the most modern and best equipped plants in America.

In this refinery it will be possible to process a daily average of approximately 43,000 barrels of Poza Rica crude together with 4000 barrels of light hydrocarbons which are necessary for the elaboration of aviation gasoline. This without taking into consideration the capacity for lubricants and paraffins, which have not yet been constructed. The average daily production in barrels of derivatives will be:

Aviation gasoline	1,000
70 octane gasoline	2,000
60 octane gasoline	13,000
Kerosine	6,000
Diesel oils	1,000
Fuel oils	19,000
Liquid gas	1,000
Refinery combustible and loss	4,000

It is believed that this production will be ample to supply the market of the central zone through 1946, with the exception of lubricants, this deficit will have to be imported even when the projected plant for its manufacture shall have been finished. At the present time, lubricants are produced in Minatitlan and in Tampico but none are produced in Atzcapotzalco.

At the present time, prior to use of new facilities, the total processing capacity of the plants at the Atzapotzalco refinery is approximately 23,000 barrels daily. This capacity is in accordance with the pumping capacity of the pipe line.

The intake at the plants is, at the present time, composed of a mixture approximately as follows:

	%
Light crude from Poza Rica (.870)	41.00
Light crude from Naranjos (.930)	23.00
Gasolines from C. Madero Refinery	23.40
Gasolines from Absorcion (ex Poza Rica)	2.60
Residues from C. Madero Dubbs Plant	10.00
	100%

From the above, the following products are obtained:

	Average daily bbls.
Motor gasoline 57/59 octane[1]	6,000
Motor gasoline 70 octane[2]	1,150
Kerosines	2,000
Diesel oils	435
Residual fuel oils	12,400
Liquiefied gas	15

[1] Tetraethyl is added.
[2] Elaborated on a basis of direct gasoline, cracking plant gasoline and added tetraethyl.

There is also the project of establishing in the state of Guanajuato a new refinery, and its installations will include primary distillation, synthesis and auxiliary plants in order to handle the markets that the Atzcapotzalco refinery may not be able to supply. This refinery will be supplied by a new pipe line from Poza Rica to Salamanca which will carry a mixture of Naranjos and Poza Rica crude. This refinery will produce the following principally (barrels daily):

Gasoline	5,800
Kerosine	2,500
Gasoil	1,500
Fuel	12,200
Refinery fuel and waste	1,800

These products will be distributed in all zones where it may be uneconomical to supply from Atzcapotzalco or Tampico.

Gulf Zone

At the present time we have in the Gulf Zone, four refineries which are: Ciudad Madero, Arbol Grande, Mata Redonda and Bellavista. The plan is to have here only two refineries which will probably be Ciudad Madero and Arbol Grande. The capacity of the two refineries that will remain in the zone in barrels daily will be:

Gasoline 70 octane	4,000
Gasoline 60 octane	6,000
Kerosine, including Diafano and tractomex	6,000
Diesel oil	5,000
Lubricants	800
Paraffin	450
Fuel oils	40,000
Asphalt and similar	5,750
Fuel in refinery and waste	7,000
TOTAL	75,000

By means of the projected distribution system, the load on the railroads will be reduced enormously and therefore it will be easy to supply all needed petroleum products throughout the republic.

Furthermore, there are possibilities of production of petroleum in the States of Nuevo Leon and Tamaulipas. If this possibility materializes, a refinery will be built in Monterey or other suitable place, as well as pipe lines to carry the oil from the fields. This will even more greatly improve the production and distribution setup.

Roumania Fast Restoring Production and Refining

Although refineries in Roumania suffered considerable damage during the war, capacity has been restored to about 77 percent of the previous total, say European press reports to *Foreign Commerce Weekly*.

The fields are said not to have been greatly damaged, and daily production had reached about 85 percent of the prewar figures at the end of 1944.

Two Major Drawbacks in Toluene Plant Disposal

Sale or lease of government-owned toluene facilities, with removal of salvage of equipment for which satisfactory sale or lease arrangements cannot be made, has been recommended to Congress by Surplus Property Administrator W. Stuart Symington.

In a report Symington disclosed that the two major problems of disposal of toluene facilities are presented by scrambled facilities and excessive capacity.

Three petroleum toluene refineries for which expenditures of more than $5,000,000 of government funds was involved were authorized, and only one of them, the Baytown, Texas, Ordnance Works, was completed, the Cities Service Refining Corporation plant at Lake Charles, Louisiana, and the Phillips Petroleum Company project at Borger, Texas, being discontinued after expenditure of less than $1,000,000. The Baytown plant has been declared surplus and is leased to Humble Oil & Refining Company. It was built at a cost of $12,821,000, all of which except $300,000 was public funds, and has a rated capacity of 6,083,000 gallons of toluene per month.

A number of projects for toluene production from petroleum were initiated at refineries, 13 of which were turning out

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April 9, 1945

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about 20 million gallons a month at the close of the war, or practically ten times the prewar production of by-product toluene from coal.

"Unless some large new use for toluene (for example, as a component of motor fuel) can be developed, it appears that either the facilities for production from coal or those using petroleum fractions will have to be diverted to other uses, such as other phases of petroleum refining," Symington reported. "This conclusion is supported by the existence of a government-owned stockpile of about 20 million gallons of toluene."

ASTM Accepts Procedures For Industrial Water Tests

American Society for Testing Materials' Committee D-19 on Water for Industrial Uses has issued several standard methods of determining various elements and ions in industrial waters, and three new methods accepted by the society's committee on standards at its August 27, 1945, meeting cover total aluminum and aluminum ion in industrial waters (D 857), manganese (D 858) and silica (D 859). In general these methods are intended to provide procedures from which the quality of water may be judged and to control water-treatment operations. The method for silica is particularly important in boiler operations so that measures can be taken to prevent the formation of complex silicate scales and to reduce the tendency of the "embrittlement" of boiler practice for sampling boiler water for stationary boilers (D 860) is another phase in the program to establish recognized methods for sampling in order to obtain the necessary analytical information to judge the quality of water.

Numerous technical papers and reports have covered procedures for testing for dissolved oxygen and after considerable study the subcommittee concerned proposed a standard test which included a method for referee and three non-referee procedures. The method of highest precision and accuracy was intended for acceptance testing of deaerating and for research testing of power-plant equipment. It is essentially the so-called Navy method which has been described in papers by Dr. R. C. Adams and others. Non-referee method B is based on the Schwartz-Gurney Method as modified by Ulmer.

In the referee method it is indicated that a skilled operator can obtain a precision of 0.002 ppm. and with an accuracy of 0.003 ppm. or 1 percent, whichever is the greater. Precision for the non-referee methods ranges from 0.004 ppm. to 0.05 ppm. of the true values. Because of numerous comments and some negative votes, it is planned to publish the proposed methods as information and for comment in the ASTM Bulletin. All those concerned have been invited to study the methods and submit comments to Committee D-19 for consideration.

Cycling Plant Planned

Warren Petroleum Company is constructing a gasoline and cycling plant, rated at 10 million cubic feet daily, in the Hull-Silk field, Archer County, North Texas. Such a project was attemped by operators during the early stages of development.

THE MONTH IN THE INDUSTRY

THE oil industry's labor impasse took on guinea pig status from still another angle when Secretary of Labor Lewis B. Schwellenbach appointed a fact-finding committee to study wage demands of the unionists whose strike is being held in abeyance by operation of the struck plants by the Navy under executive order. The committee is in line with the ideas of President Truman who has the Congress busy on legislation designed to set up such fact-finders in all labor disputes. Members of the committee include Dr. Frank P. Graham president of University of North Carolina and member of the War Labor Board; Paul Eliel of Stanford University, and Otto Beyer, labor advisor, formerly with the Department of Labor. Some criticism of this panel has been expressed by men of the oil industry, on the basis that its members, and particularly Dr. Graham, may have predilections favoring CIO. Union overlords are unanimously against the fact-finding idea of the President, Congress is apathetic, and the public has not been consulted. The oil industry fact-finding committee is without authority of law or precedent, but it has organized, with representatives of the companies and of the union acquiescent by attendance. Public hearings are to start December 17, and decision is due January 10.

The oil industry ended its wartime partnership with the government December 12, when the Petroleum Industry War Council formally dissolved, leaving up in the air the question whether a new organization could be created for peacetime cooperation without running counter to the antitrust laws.

The final session of the council was preceded by a testimonial dinner to William R. Boyd, Jr., president of the American Petroleum Institute, who acted as chairman of PIWC throughout the war period.

Senate's Current Oil Probe Ended

Despite the drain of the war years there is no danger of the United States running out of liquid fuels in the foreseeable future, but discovery and development of continuing supplies must be handled by private industry, with the help of the government but without unnecessary regulation, Petroleum Administrator Harold L. Ickes told the Senate Special Petroleum Committee November 30 as it prepared to close its review of PAW operations.

Ickes was emphatic in his assertion that the industry-government partnership developed during the war should be continued.

Also of pressing need for the benefit of the industry is the concentration of government administration, now scattered among a number of agencies, Ickes told the committee.

Major needs of the country and industry, Ickes said, are: stimulation of exploration; efficient use; advancement of technology in finding and developing oil resources and in refining, and assurance of access to foreign resources to supplement domestic production as needed.

Possibilities that world oil demand for may be as long as a year or two may recede to prewar levels were seen by William B. Heroy, director of the foreign production division.

This condition, he said, will not be due to United States demand, which will continue heavy, but "it will be sometime before European countries whose internal economy has been disrupted by the war, will return to a normal level of consumption."

Any postwar adjustments in world petroleum supply, resulting from reduced world requirements, should be so distributed that the economy of foreign countries in which petroleum is an important industry shall receive reasonable recognition and their local petroleum industries shall continue in a healthy condition, he contended.

The capacity of world markets to absorb refined products also will be a major factor in the probable future trend in construction of foreign facilities, it was pointed out by S. Stribling Snodgrass, director of the Foreign Refining Division.

Continued expansion in the use of natural gas for fuel and power; further conservation and reduction of waste, a continued high discovery rate, and greater use of gas in the manufacture of chemicals and plastics are the postwar expectations in the field of natural gas, it was testified by James E. Pew, director of the Natural Gas and Natural Gasoline Division.

Stroop Named Assistant To President of API

David V. Stroop has been appointed assistant to the president of the American Petroleum Institute, a new position created by the board of directors at the recent annual meeting in Chicago.

Stroop joined the API February 1, 1928, as staff engineer. Subsequently he became director of the Department of Engineering, and in 1933 was appointed secretary of the division of marketing. In 1942 his duties were incraesed when he was appointed director of the department of accident prevention, and again during the past year when he has served also as secretary of the Division of Refining. During the three years of war he was also the executive secretary of Petroleum Industry War Council's committee on protection of petroleum facilities.

He was graduated by George Washington University in 1921 with a degree in civil engineering. In 1939 he received his LLB, after completing his evening study of law at New York Law School. From 1910 to 1919 he was surveyor and junior engineering in the Office of Public Buildings and Grounds at Washington, and from 1919 to 1921 was assistant district engineer of the U. S. Forest Service at Portland, Oregon.

He served as district manager for the Berrett Company at Washington in 1921 and 1922, and in 1922 became superintendent at construction for Charles H. Thompkins Company, also at Washington. In 1924 he was appointed associate engineer at the National Bureau of Standards which he left in 1928 to join the API staff.

Differences Delay Research Legislation

Extent of government control over scientific research currently is the subject of controversy which is delaying consideration by Congress of legislation establishing a national research foundation and correlating the research activities of industry, educational institutions, research foundations and the government.

The two sides of the controversy are presented in bills sponsored by Senators Harley M. Kilgore of West Virginia and Warren G. Magnuson of Washington, the latter measure being more to the liking of industry, which is destined to play an important role in postwar research.

A major difference between the bills is in the structure of the proposed foundation. The Kilgore bill made it almost exclusively government, but the Magnuson bill provided for the formation of advisory committees composed of especially qualified scientists, and in recognition of the desirability of the latter, Kilgore introduced a new version of his measure incorporating the provisions of the Magnuson bill.

Bureau Gets Ammonia Plant for Fuel Research

Under an arrangement with Quartermaster General of the Army, the Bureau of Mines will convert the synthetic ammonia plant at Louisiana, Missouri into a demonstration plant for the production of gasoline and oil from coal and lignite. This selection completes the plant selection as provided for in the $30,000,000 appropriation under which the Bureau of Mines will develop and make available to private industry the know-how for production of synthetic liquid fuel from coal and shale. Other installations now under construction include coal research and development laboratory at Bruceton, Pennsylvania, oil shale demonstration plant at Rifle, Colorado, and the oil-shale research and development laboratory at Laramie, Wyoming.

The Bureau of Mines will convert the Louisiana plant at its own expense with the provision that all changes must be so made that the plant may be reconverted to ammonia production in an emergency.

The conversion will provide for two

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THE MONTH...

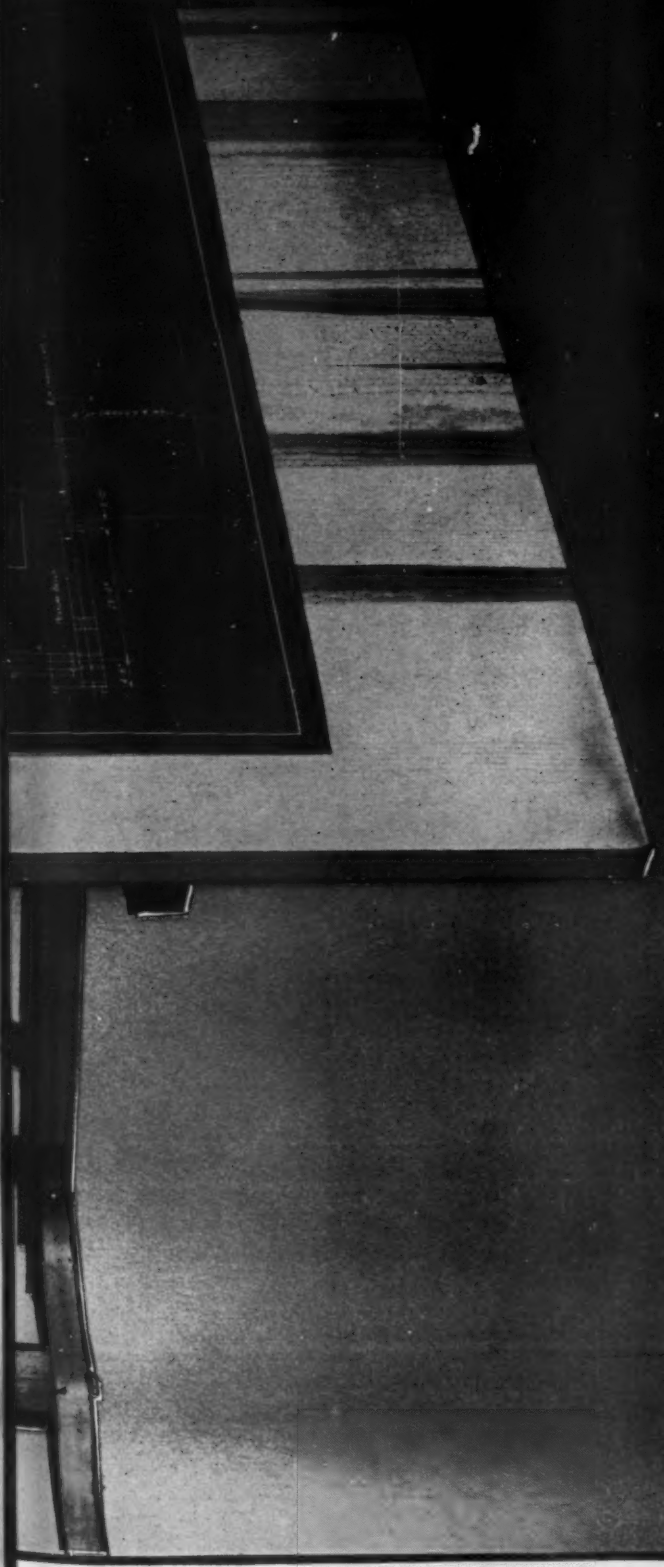
distinct units, one using direct hydrogenation and the other employing the indirect gas synthesis process. The processes have been further described in the news release of the Department of the Interior as:

"The direct hydrogenation process is employed in both Germany and England. Under this method coal is converted into oil by removing the oxygen and increasing the hydrogen. This is done by mixing the coal with oil to form a slurry or paste and pumping it with hydrogen gas into a converter. At high temperatures and pressures and in the presence of a catalyst to promote the reactions, the hydrogen removes the oxygen then converts the coal to oil. This oil is treated further to yield gasoline or a wide variety of other products, including materials for synthetic rubber and plastics, and medicinals. The gasoline has a fairly high octane number without further processing, and this process was used by the Germans as their chief source of aviation fuel. One ton of coal will yield up to 70 or 80 gallons of gasoline and, at the same time, supply all the power and heat needed to operate the plant.

"Having conducted laboratory studies on coal hydrogenation since 1936, the Bureau of Mines has determined the oil yield of coals from various sections of the United States and Alaska, developed special catalysts to increase the oil yield, discovered a low-pressure process particularly suited to the production of fuel oil, and accumulated considerable information on the influence of various operating conditions such as temperature and pressure. More important, this research has trained a nucleus of skilled technicians who now have the knowledge to proceed with a large-scale development.

"The second process for converting coal or lignite to oil is the indirect gas synthesis method which has had its greatest application in Germany. In this process, coal or coke is burned in such a manner as to give off carbon monoxide and hydrogen gases. These are purified and at carefully controlled temperatures are passed over a catalyst, causing the gases to react and produce carbon-hydrogen compounds similar to oil and gasoline which may be refined further by methods normally used in the petroleum industry. Yielding about the same amount of gasoline and oil per ton of coal as the hydrogenation method, the gas synthesis process also offers a superior grade of diesel fuel and these various products can be converted by further refining to a great variety of useful materials, including lubricating oils and greases, synthetic rubber, alcohols, fatty acids, soaps, and edible fats such as margarine. These products, together with the organic chemical obtained by the hydrogenation process, are essential to national defense.

"Laboratory investigations of the Bureau of Mines in the gas synthesis field have been conducted only within the last several years. However, from this limited work and from information obtained in Germany, it is evident that major modifications will greatly lower the cost of the final product and that the process has important possibilities."



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Plans coming from the industry's drafting boards today will determine the course of oil operations for the years ahead. They will provide the new techniques and equipment necessary to accomplish the big job of finding, producing and refining the enormous quantities of oil needed to offset wartime's heavy drain on petroleum supplies. Republic's supply service is tuned to these plans and **"Your Supply Store"** will be on hand at the right places, at the right time, with adequate stocks of everything best in materials and equipment required to get the job done.

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THE MONTH...

Pure Announces Refinery Division Appointments

Oliver B. Wendeln, superintendent of The Pure Oil Company's Midland refinery, Midland, Michigan, was transferred to the refinery control board section in the Chicago headquarters of the company. Harold L. Smith, former superintendent at Toledo refinery, is returning from a leave of absence to become superintendent at Midland.

Hal H. Dronberger, who has just been placed on inactive duty status after 38 months in the Navy (lieutenant commander) rejoins the company as assistant superintendent at Toledo refinery. His service with the company began in June, 1926, and he has worked at Nederland, Texas; Newark, Ohio; Marcus Hook, Pennsylvania, and Toledo. Thirteen months of his Navy duty were at Midway Island where he was operations officer. Another recent assignment was as aviation fuel supply officer for the First Naval District.

Dale G. Miller, acting assistant superintendent at Toledo, will become assistant superintendent of Heath refinery at Newark, Ohio. He is in his fifteenth year with the company.

Bowman to Develop Market For Jefferson Chemical

Dr. William H. Bowman has been appointed market development manager for Jefferson Chemical Company, and will be responsible for organizing market research, market development and sales and technical service facilities. He comes to this connection from Westvaco Chlorine Products Corporation, where he was manager of the technical service and market development division. Prior to that he held research and development posts with Shawinigin Chemical, Ltd., and Armstrong Cork Company. He also has served as a member of the chemical engineering and chemistry faculties of University of Toronto, New York University and Case School of Applied Science. He is a member of the executive committee of both the Chemical Market Research Association and the Technical Service Group of the Chemical Industry.

Socony-Vacuum Refinery Committeemen Named

D. L. Hooker has been appointed vice chairman of the manufacturing committee of the Socony-Vacuum Oil Company, Inc. George S. Dunham, manager of the refinery engineering department, will represent the Midwest refineries on the committee.

Other appointments, which were announced by Clark S. Teitsworth, chairman of the committee, were those of J. B. Middleton to the manufacturing committee as manager of foreign refinery operations, and S. D. Dalton as chief refinery engineer.

Asphalt Plant Work

California Asphalt Corporation, subsidiary of Standard Oil Company of California, has awarded contracts on two items for its new asphalt plant near Portland, Oregon.

The Fluor Corporation of Los Angeles was awarded contract for installation of process equipment while Chicago Bridge & Iron Company of Chicago will construct tankage.

Hooker Electrochemical Establishes Laboratory

Dr. L. J. Brady, formerly a fellow at the Mellon Institute of Industrial Research, is director of a physical research laboratory organized by Hooker Electrochemical Company, Niagara Falls, New York. Primary function of the laboratory is to provide physical analyses and controls for all phases of the company's chemical work. Types of work include infrared and ultraviolet spectroscopy.

Dr. Brady received his B. S. from Utah State College of Agriculture, and his M. S. and Ph. D. from Pennsylvania State College.

Rumor Sets Up New Resources Department

Rumors that President Truman would establish a new department of natural resources under the war powers act, with Secretary of the Interior Harold L. Ickes its head, could not be traced to any responsible quarters in Washington.

The reports, however, did focus attention upon consideration being given to both centralization of administration over those resources and legislation which has been introduced in Congress to set up a board to make natural resources policies.

At the same time, there reportedly is a school of thought, scattered among the various departments, that the authority of the war powers act should be continued and that under them, government by fiat be set up in lieu of the present checks and controls of the legislative-executive set-up. On the other and

DR. J. L. BRADY

Crude Oil Runs to Stills, Production of Refined Products, and Stocks for the Four-Week Period Ending December 1, 1945

(Figures, in thousands of barrels of 42 U. S. gallons each, based on reports of American Petroleum Institute. Production and stocks include reported totals plus estimated amounts to make these figures on a Bureau of Mines Basis)

DISTRICT	Capacity Percent Reporting	Crude Runs to Stills: Daily Average	Crude Runs to Stills: Percent Operating	Production: Gasoline*	Production: Kerosine	Production: Gasoil and Dist. Fuel Oil	Production: Residual Fuel Oil	Stocks at Refineries, Terminals and in Pipe Lines: Finished and Unfinished Gasoline	Stocks at Refineries, Terminals and in Pipe Lines: Kerosine	Stocks at Refineries, Terminals and in Pipe Lines: Gasoil and Dist. Fuel Oil	Stocks at Refineries, Terminals and in Pipe Lines: Residual Fuel Oil	Crude Oil: Daily Average Production	Crude Oil: Stocks†
East Coast	99.5	814	103.2	8,082	1,063	3,809	7,197	18,562	4,874	15,593	8,008	.....	.....
Appalachian District 1	76.8	100	68.5	1,528	204	291	271	2,675	414	634	219	.....	.....
Appalachian District 2	81.2	55	111.0	695	56	155	353	852	38	134	207	.....	.....
Indiana, Illinois, Kentucky	87.2	761	88.8	11,439	1,096	2,648	3,978	17,183	2,449	6,352	3,141	.....	.....
Oklahoma, Kansas, Missouri	78.3	349	74.5	5,460	534	1,331	1,790	7,606	875	2,808	1,108	.....	.....
Inland Texas	59.8	226	67.7	4,069	337	402	1,581	2,881	279	435	950	.....	.....
Texas Gulf Coast	89.3	1,140	92.2	15,676	2,342	5,943	6,702	14,989	1,818	5,993	4,834	.....	.....
Louisiana Gulf Coast	96.8	295	113.4	3,463	1,045	1,744	1,588	3,910	996	1,990	1,589	.....	.....
North Louisiana-Arkansas	55.9	58	46.4	705	129	242	414	1,726	207	525	339	.....	.....
Rocky Mountain District 1	17.1	13	98.1	144	24	42	120	106	20	19	31	.....	.....
Rocky Mountain District 2	72.1	103	66.2	1,588	68	332	882	1,627	103	512	723	.....	.....
California	86.5	837	81.3	9,422	224	2,071	9,785	13,859	436	9,279	25,385	.....	.....
Total U. S. Dec. 1, 1945	85.7	4,705	87.0	62,271	7,122	19,010	34,661	85,976	12,509	44,274	46,534	4,448	218,845
Total U. S. Nov. 3, 1945	85.7	4,807	88.9	.....	.....	.....	.....	76,551	12,705	44,810	46,128	4,318	221,031
Total U. S. Dec. 2, 1944	....	4,693	....	.....	.....	.....	.....	80,689	13,800	45,385	61,944	4,712	221,591

* Includes natural gasoline blended at refineries. † Bureau of Mines.

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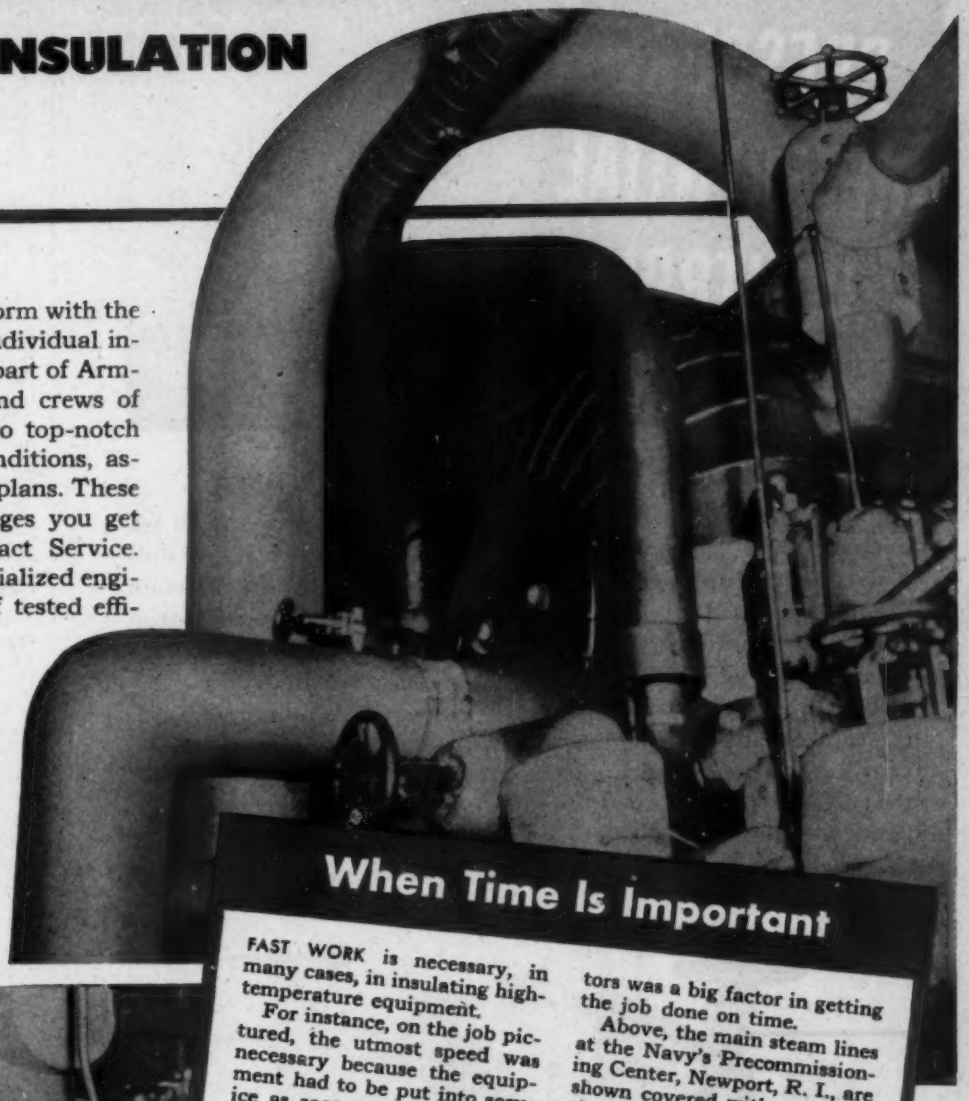

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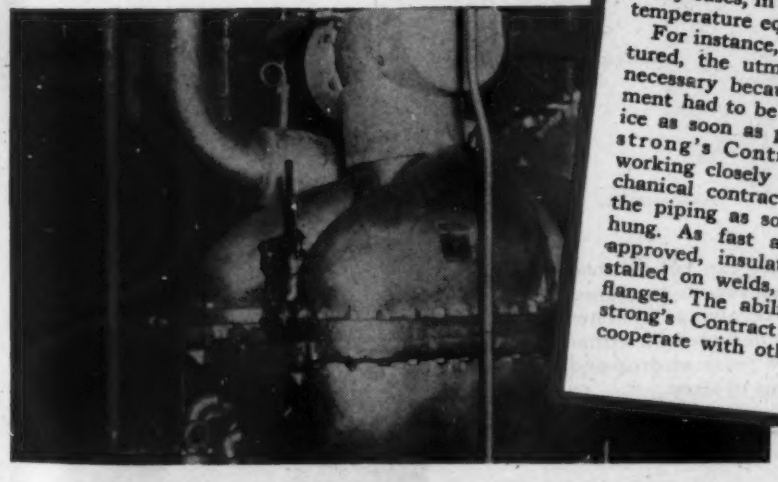
Above, the main steam lines at the Navy's Precommissioning Center, Newport, R. I., are shown covered with combination high-temperature and 85% Magnesia insulation, finished with asbestos cloth jacket sewed over asbestos paper.

At left is the 250 KW Turbo Generator, covered with 2" of plastic insulation and finished with hard surface asbestos. Also shown is the atmospheric relief valve, insulated with removable asbestos blankets and finished with asbestos cloth.



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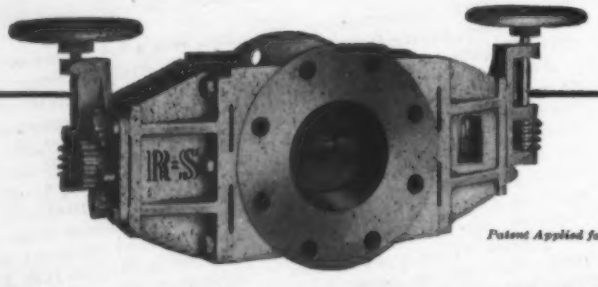
The hydraulic controller, connected to the 125-pound R-S Valve, is set for a predetermined differential based on operating conditions. If there is a pressure of 50 psi at A and 49½ psi at B with the valve wide open, the sudden failure of the pump causes pressure A to drop and the valve slowly closes. As soon as the proper pressure differential is restored, the valve will re-open.

CONDITION 2

If there is a pressure of 50 psi at A and 49½ psi at B, the sudden rupture of the downstream line causes pressure B to drop and the valve closes. Manual re-opening is usually required.

Extremely flexible in the handling of a multitude of materials, these valves are also adapted to elevated or sub-zero temperatures. 15 to 900 psi. Precision engineered, metallurgically and mechanically.



No. 642. Close control of volume and pressure can be obtained with this dual-purpose valve. The larger beveled vane seats against the valve body, while the smaller vane is free revolving. Operates beyond the limitations of a single valve and is designed for either a high pressure drop and small volume or a low pressure drop and large volume. Available in various combinations of sizes.

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THE MONTH...

more controlling hand, Congress is determined that the war powers shall be revoked at the earliest opportunity and House-approved legislation sets next June 30 at their expiration date.

More in line with Ickes' thinking would be a centralization of federal authority over oil in the Interior Department, where he would concentrate all the activities now exercised by more than 30 agencies.

Senator Pat McCarran has introduced legislation creating a Natural Resources Council and there have been suggestions that if the measure is enacted Ickes might accept the top post in the organization.

The report of the creation of a new department probably originated on the basis of legislation now in Congress authorizing the President to reorganize the federal establishment.

The reorganization bill, however, does not authorize the President to change the departmental set-up, but merely to re-shuffle the lesser units in the interests of efficiency and economy.

Atlantic Refining Company Promotes Stroud and Shaw

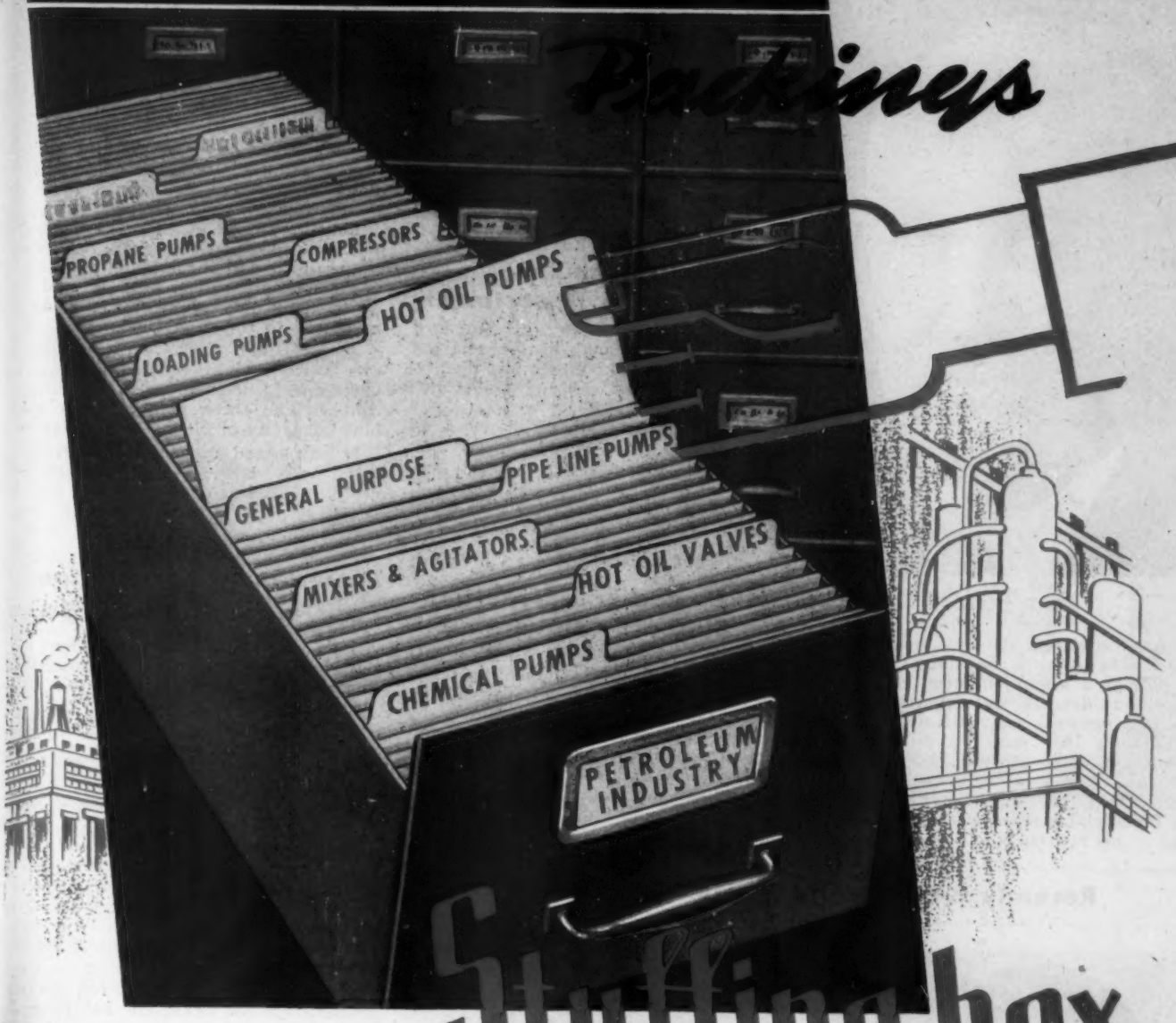
W. F. Stroud has been named plant manager of the Philadelphia refinery of The Atlantic Refining Company, with D. T. Shaw as his assistant. Their promotions followed recent retirement of Howard N. Nichols.

Stroud had his degree in mechanical engineering from New York University, and joined The Atlantic Refining Company in 1916 as an assistant engineer in the power house. After two years he transferred to the gas department, and in 1925 became a process engineer in the research and development department. He has been assistant superintendent since 1927.

Shaw received A.B. from Oberlin College in 1914 and M.A. at Brown University in 1916. After 13 years in varied

W. F. STROUD

DURAMETALLIC Packings



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For over 25 years this company has devoted itself exclusively to serving the sealing needs of industry. This experience — this record file — are at your disposal when you use Durametallic Packings and Seals. Durametallic products are truly "Engineered For The Job." Call on us to submit recommendations . . . let our "Success Record" File help you today.

DURAMETALLIC PRODUCTS . . .

- FLEXIBLE METALLIC PACKING
- PLASTIC PACKING
- MECHANICAL SEALING DEVICES
- OIL PRESSURE SYSTEMS
- FLEXIBLE HANDLED PACKING TOOLS

DURAMETALLIC CORPORATION

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NEWARK • NEW ORLEANS • PITTSBURGH • ST. LOUIS • SAN FRANCISCO • SEATTLE • TULSA • YOUNGSTOWN, O.

THE MONTH . . .

D. T. SHAW

chemical research and development, he joined The Atlantic Refining Company in 1929 as a senior engineer in the research and development department. He has been general superintendent of the plant since 1937 until his most recent promotion.

Nichols had been with the company since 1904, and had been manager of the Philadelphia refinery 22 years at the time of his retirement.

Michigan Refinery Will Have Small TCC Unit

Leonard Refineries, Inc., Alma, Michigan, has contracted with Houdry Process Corporation for erection of a 3000-barrel-daily-charge-capacity Thermofor Catalytic Cracking unit.

While the unit embodies a number of design simplifications, it is in principle very similar to the larger TCC units. Simplifications include integral elevator design for both spent and regenerated catalyst. Increased catalyst rates make possible elimination of vapor superheaters. The structure has been substantially simplified and the overall height has been reduced.

Stanolind Organizes Manufacturing Department

J. E. Rouse, formerly with Standard Oil Company (Indiana), has been named manager of the manufacturing department of Stanolind Oil and Gas Company, Tulsa.

The new department, to be set up as of January 1, will be responsible for sale of all manufactured products; purchase and sale of gas, and planning, designing and handling of all technical matters relating to operations of proposed gasoline, cycling and repressure plants.

High-Priced Butadiene Units Are Closed By Government

Six government-owned plants that have been producing butadiene and styrene, three of them based on petroleum, have been ordered closed down by Rubber Reserve Company because supplies no longer are needed for the synthetic-rubber program.

The three petroleum-based plants are those of Humble Oil & Refining Company, Ingleside, Texas; Lion Oil Refining Company, El Dorado, Arkansas, and Taylor Refining Company, Corpus Christi, Texas.

The other three plants, which had been producing butadiene and styrene from alcohol, are two plants of Carbide and Carbon Chemicals Corporation at Institute, West Virginia, and Louisville, Kentucky, and the Koppers Company, Inc., plant at Kobuta, Pennsylvania. They have been placed in standby condition.

It was explained that the alcohol plants were suspended for the added reason that their production costs were about three times as high as those of the petroleum plants.

The three refinery plants closed were also in the high-cost bracket. They were converted to butadiene production early in the synthetic-rubber program and had contributed only about 13,000 tons of butadiene to the program.

The closing of the alcohol plants marks the end of the manufacture of butadiene from that base for synthetic rubber. The three plants had a combined capacity of 210,000 tons a year.

It was stated that butadiene from alcohol was costing approximately 40 cents a pound as compared with 8 to 10 cents a pound when produced from petroleum.

Government Corporations Lose Financial Independence

Legislation divesting government corporations of much of their financial independence was signed December 6 by President Truman.

Each corporation must submit annually a budget program through the Budget Bureau, and Congress will make definite appropriation of funds and other resources. The financial transactions of government corporations, further, are to be audited and a report of each audit for the preceding fiscal year is to be submitted to Congress, showing such information as may be deemed necessary to keep Congress informed of the operations and financial conditions of the several corporations.

The measure also calls for the discontinuance of operation by June 30, 1948, of all the corporations created under the laws of any state, territory or other jurisdiction. Committee investigation developed that 18 existing government corporations were organized under non-federal charters, including the highly controversial Petroleum Reserves Corporation.

New Owners to Operate National Refining Company

Properties of National Refining Company have been sold to a group headed by Wallace Gilroy, president of Interstate Gas Company. He was engaged in the refining industry in Michigan, first as president of Imperial Refining Company and became chairman of the board of Mid-West Refining Company, when it was merged with the other company.

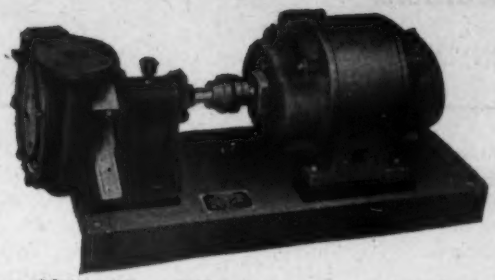
The new owners plan to modernize the National plant at Findlay, Ohio, and to continue operations under brand names long established in the Middle West. Two years ago the company sold its plant and some other properties at Coffeyville, Kansas.

Recently Promoted by The Texas Company

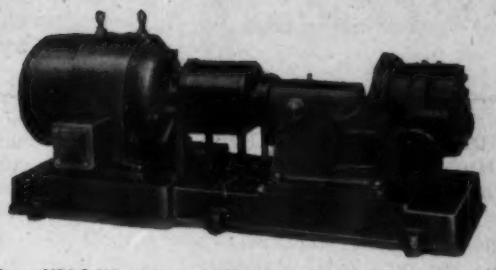
D. P. BAILEY
Assistant Works Manager at Port Arthur.

F. H. HOLMES
General Superintendent at Port Arthur.

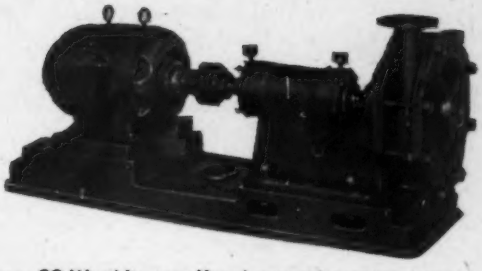
PUMPING CORROSIVE LIQUIDS



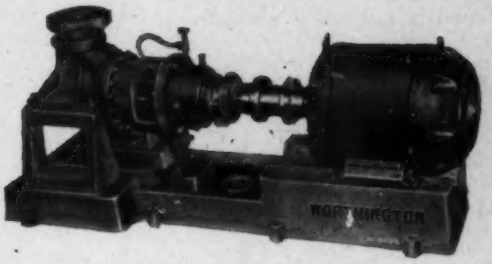
Type CG Worthite centrifugal pump . . . open impeller . . . capacities to 3000 GPM . . . heads to 150 ft. Bulletin W-350-B1F.



Type HBLC Worthite centrifugal pump . . . vertically split . . . capacities to 240 GPM . . . heads to 540 ft.



Type CQ Worthite centrifugal general-purpose pump . . . capacities to 600 GPM . . . heads to 130 ft. Bulletin W-350-B3F.



Type HR centrifugal pump . . . capacities to 1800 GPM . . . heads to 900 ft. . . . temperatures to 800°F. . . . pressures to 750 PSI.

Worthington Corrosion-Resistant Centrifugal Pumps Cover the Broadest Range

Throughout its long pumping experience, Worthington has analyzed and solved many refinery corrosion and abrasion problems. As a result, the corrosive liquid or corrosive-abrasive slurry now troubling you can probably be successfully handled by a Worthington Centrifugal Pump.

Most corrosive conditions fall within the range of *standard* Worthington Chemical Pumps. Worthite has also proved economical to use in severe corrosive-abrasive conditions.

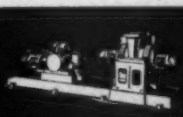
Worthite . . . a high-nickel, high-chromium, molybdenum, low-carbon alloy steel . . . is widely recognized as giving maximum resistance to both corrosion and abrasion. Worthite parts . . . valves, plugs, bars, etc. . . . may prove to be the answer to your difficulty.

To learn whether *there's more worth in Worthington*, discuss your problem with a Worthington Pump Application Engineer—without cost or obligation. Write today or telephone the nearest of our 36 branch offices. *Worthington Pump and Machinery Corporation, Harrison N. J.*

WORTHINGTON

24CS-E

WORLD'S LARGEST MANUFACTURER OF PUMPS



Type HD. Hydraulically balanced for refinery process work at temperatures up to 850°F. and pressures up to 550 p.s.i., with the use of suitable materials. Capacities up to 3200 g.p.m., at heads up to 700 ft.

Type LT. Nine sizes. Capacities to 2500 g.p.m. Developed heads to 900 ft. Horizontally split case for temperatures up to 600°F. and pressures to 400 p.s.i.

Type HL. Several construction arrangements permit flexibility in application. Designed for temperatures up to 225°F., or higher with water-jacketed stuffing box. Capacities up to 3600 g.p.m., heads to 500 ft.

DIGEST OF UNITED STATES PATENTS

On Refining of Hydrocarbons

Compiled by HEINZ HEINEMANN

U.S.P. 2,356,095. Process for the Purification of Hydrocarbon Liquids. W. A. Schulze to Phillips Petroleum Company.

Readily polymerizable impurities in hydrocarbons are removed by contacting the hydrocarbons at atmospheric temperature with a substantially completely dehydrated adsorbent carrier (such as bauxite, alumina, silica or clays) supporting anhydrous aluminum chloride. The hydrocarbon liquid is contacted with 1-3 percent of the reagent containing 30-60 percent $AlCl_3$, and the treated liquid is redistilled after an alkaline wash.

U.S.P. 2,356,890. Process for the Dehydration of Fluids. W. A. Schulze to Phillips Petroleum Company.

An agent for the dehydration of hydrocarbon fluids is prepared by spraying activated bauxite with a concentrated solution of lithium chloride to give masses containing from 3-13 percent by weight of L_iCl. the mass is dried at 400-600° F. and used in beds, the lithium chloride concentration of which increases in the direction of flow.

U.S.P. 2,361,455. Method of Neutralizing Hydrocarbon Oil. V. L. Chechot to The Atlantic Refining Company.

Acid-treated oils which normally form emulsions upon neutralization may be neutralized without emulsification and without the use of rosin soaps or similar agents by subjecting them to treatment with an aqueous solution of an alkali metal silicate with or without the addition of an alkali metal hydroxide.

U.S.P. 2,364,502. Fuel Compositions. J. C. Zimmer and J. I. Wasson to Standard Oil Development Company.

Fuels are stabilized against deterioration by addition of an agent characterized by metal salts of resinous condensation products formed by reacting an alkyl phenol with formaldehyde and HCl and then reacting the condensation product with ammonia.

U.S.P. 2,364,517. Solvent Extracting Gasoline. R. E. Burck to The Standard Oil Company (Ohio).

Gasoline products are efficiently separated from hydrocarbon mixtures by selective pressure extraction in the liquid phase operated in the neighborhood of the distillation temperature of the gasoline. Suitable solvents are phenylene diamine, phenyl ethanol amine, diethanol amine, etc.

U.S.P. 2,363,011. Catalytic Demuriation. J. C. Michalek and E. R. Eickson to Mathieson Alkali Works, Inc.

Halogen-bearing organic compounds are demuriated in the presence of a supported catalyst, consisting of an intimate mixture of a phosphate of alkaline earth metal with a phosphate of chromium, cobalt or manganese. The ratio of the two phosphates is about 2:1. The carrier is preferably a synthetic or natural aluminum oxide or silicate.

U.S.P. 2,363,515. Hydrocarbon Oils. B. B. Farrington, J. O. Clayton and D. H. Etzler to Standard Oil Company of California.

The addition to a lubricating oil of small amounts of a metal salt of an aliphatic carboxylic acid, carrying a substituted or unsubstituted carboxylic acid group in addition to the salt-forming carboxylic acid group and carrying in addition to said groups an ether substituent or a keto substituent, or a sulfur, selenium or tellurium analogue of said ether substituent, atached to an aliphatic carbon atom, brings about an improved stability in hydrocarbon oils when the same are subjected to high temperatures or pressure in the presence of oxygen and metals.

U.S.P. 2,366,936. Treatment of Hydrocarbon Oils. W. A. Schulze to Phillips Petroleum Company.

The process for reducing the corrosiveness of hydrocarbon fluids containing oxygen upon metals is claimed which comprises commingling with a reducing gas in sufficient quantity to react with a substantial portion of the oxygen and subjecting the mixture to a pressure of at least 5 atmospheres at a temperature of from -30 to 200° F.

U.S.P. 2,367,803. Method of Refining Hydrocarbon Oil. H. Schindler to The Pure Oil Company.

Copper present in hydrocarbon distillates can be removed by contacting the distillates with materials having cation-exchange properties, such as oil-insoluble solid organic resinous condensation products. Such resins may be prepared by condensing mono or poly-hydroxy phenols with formaldehyde in the presence of sodium sulphite.

U.S.P. 2,368,554. Process for Refining Hydrocarbons. G. A. Lorenz to Shell Development Company.

Diolefins are removed from cracked gasoline without excessive polymerization of mono-olefins by fractionating the distillate into a lower- and a higher-boiling fraction, containing the higher-boiling fraction in the vapor phase with a dilute aqueous solution of a strong free oxy acid for periods of from 3 to 300 seconds and also contacting during that period the lighter fraction in the vapor phase with the mixture from the first contact. The reaction temperature must be below cracking and preferably is between 200-400° F., when employing sulfuric acid, sulfonic acid and hydrosulfates as contact agents and between 250 and 750° F. when using phosphoric acid.

U.S.P. 2,369,497. Method of Preparing An Improved Motor Fuel. A. L. Stanly to Shell Development Company.

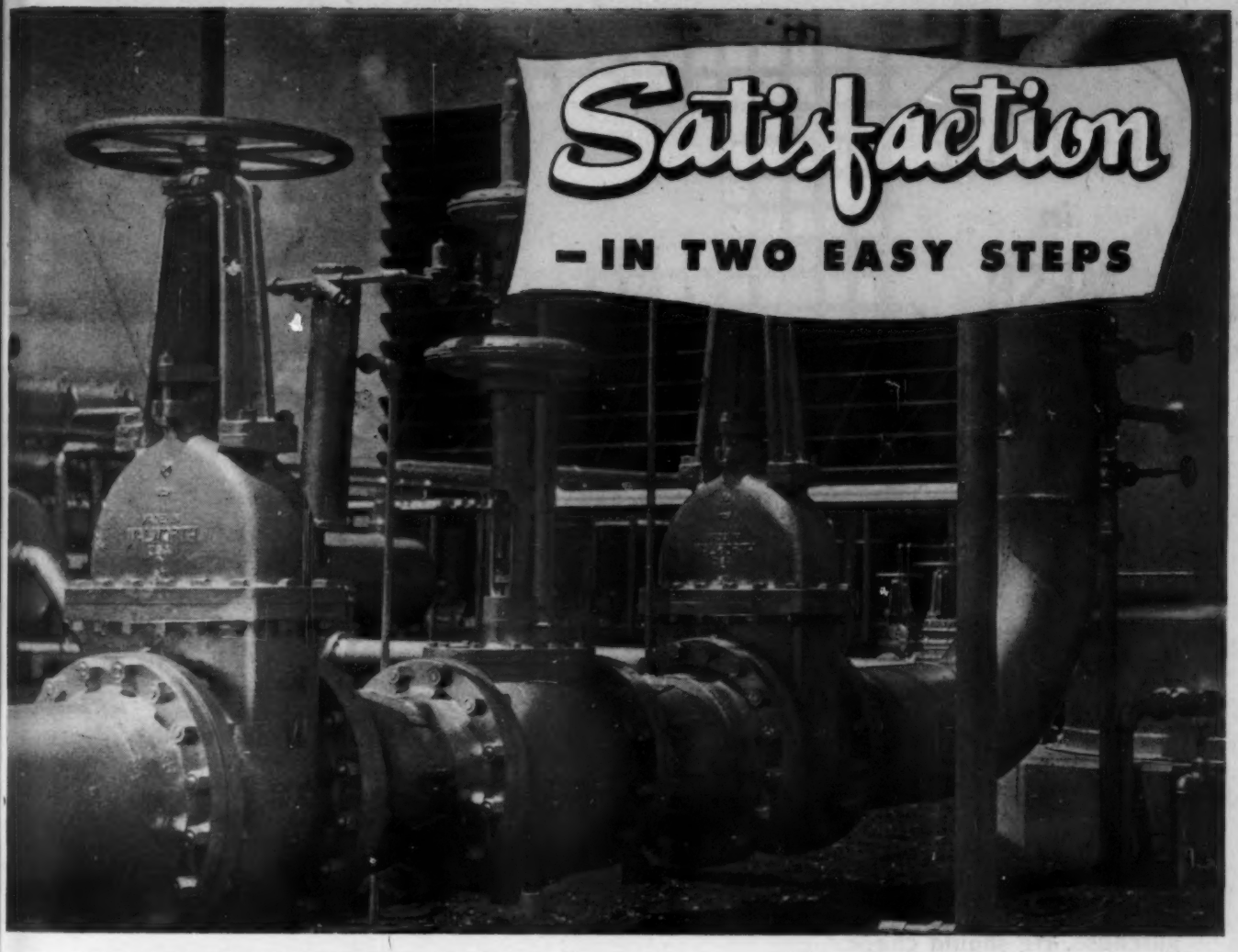
Concentrated mixtures of aromatics obtained by extracting hydrocarbon fuels usually have lower maximum power outputs than pure aromatic blending agents because the extracts normally include fairly large proportions of harmful non-aromatic compounds. Aromatic concentrates of better power outputs can be obtained by solvent extraction of a gasoline distillate of relatively wide boiling range and subsequent fractional distillation of the extract to remove the lower-boiling constituents.

U.S.P. 2,371,342. Process for Treating Hydrocarbons. F. D. Mayfield to Phillips Petroleum Company.

In a process of separating an aliphatic C_4 olefin from a C_4 hydrocarbon mixture containing the same and other close-boiling more saturated C_4 hydrocarbons which comprise introducing said C_4 hydrocarbon mixture continuously into a combination extraction and rectification column at an intermediate point between the top and the bottom of said column, continuously introducing liquid acetone as a selective solvent for said olefin to the top of said column, simultaneously fractionally distilling and solvent extracting said hydrocarbon mixture in said column, supplying heat to the bottom of said column, refluxing the top of said column, continuously withdrawing from the top of said column a stream of hydrocarbon vapors depleted in said olefin, continuously withdrawing from the bottom of said column a stream of said acetone enriched in said olefin, and in which process the ratio of acetone to total hydrocarbons in the liquid phase normally drops sharply at an intermediate critical point in the column to a value so much less than its value in the top of said column as to limit substantially the percentage of the olefin in the hydrocarbon dissolved in the enriched acetone bottom product, the improvement which comprises increasing said ratio of acetone to total hydrocarbons in the liquid phase substantially at said critical point to a value such that below said point said ratio has a volume at least about equal to its value in the top of said column, and thereby substantially increasing the percentage of the olefin in the hydrocarbon dissovled in the enriched acetone bottom product.

U.S.P. 2,372,668. Process for Selective Absorption. K. H. Hachmuth to Phillips Petroleum Company.

Greatly improved results may be obtained in the extractive distillation of low-boiling aliphatic olefins and diolefins from hydrocarbon streams by means of furfural as the solvent if the furfural is removed from the system either periodically or continuously and treated to



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FRANKLIN SELECTIVE PROCUREMENT SERVICE

There's a simple, direct, complete answer to getting the right valves and fittings *for any piping need*—the trusted name WALWORTH. It identifies a complete line of correctly engineered products whose design and construction are dictated by practical oil country experience.

There's an equally good way—simple, direct, complete—to simplify your basic buying problem; Franklin Selective Procurement Service. Used as an integrated part of your purchasing procedure, it is an effective means of getting *what you want, when you want it.*

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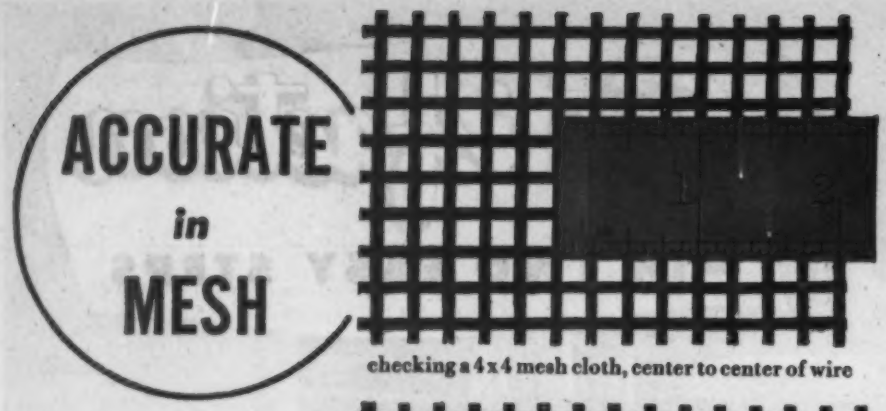
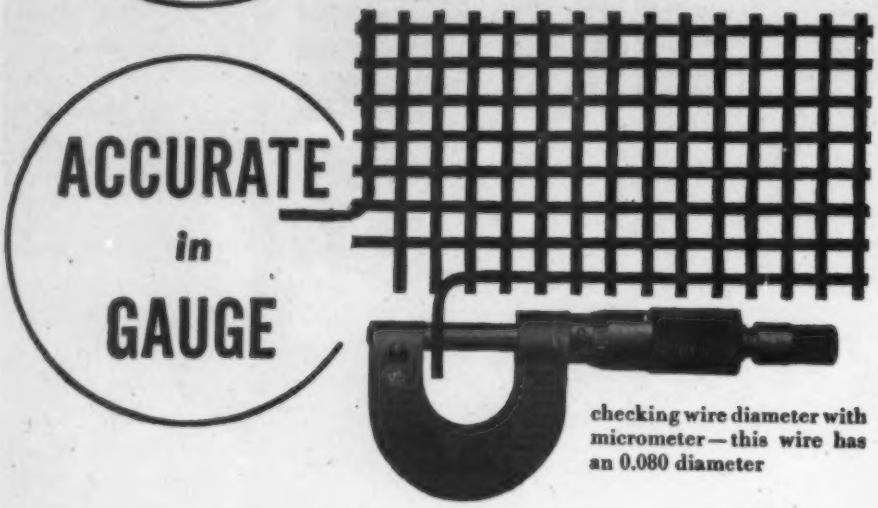


checking a 4 x 4 mesh cloth, center to center of wire



checking wire diameter with micrometer—this wire has an 0.080 diameter

Every buyer of wire cloth should make spot checks of his purchase. He should check:

1 . . . diameter of wire
2 . . . mesh count
3 . . . precision of weaving
4 . . . proper crimping

NEWARK Wire Cloth is noted for its accuracy in mesh and gauge and in the precision and uniformity of its weaving and crimping. Several factors contribute toward this reputation. Perhaps the underlying one is that years ago—in 1877—we set out to establish a reputation for making high quality wire cloth. We earned that reputation. We feel that is is but good business to maintain it.

The next time you want "quality" wire cloth, try NEWARK.

NEWARK for ACCURACY

NEWARK WIRE CLOTH COMPANY
334 VERONA AVENUE NEWARK 4, N. J.

free it from polymers before its reintroduction to the system.

U.S.P. 2,373,021. Stabilization of Petroleum Hydrocarbons. F. B. Downing and C. J. Pedersen to E. I. du Pont de Nemours & Company.

In order to prevent oxidation of hydrocarbons furthered by the presence in the hydrocarbons of traces of catalytically acting metals like vanadium, magnesium, iron, copper and their compounds, a metal deactivator is added in a small proportion, sufficient to deactivate the catalyst. Guanylguanidines are proposed as suitable deactivators.

U.S.P. 2,375,675. Process of Treating Hydrocarbon Materials. M. P. Matuszak to Phillips Petroleum Company.

Hydrocarbon materials can be advantageously freed of substantially all unsaturated hydrocarbons, resins, sulfur compounds, color and/or gum-forming compounds and the like by treating these hydrocarbon materials with substantial amounts of hydrogen fluoride, which is free from the oxidizing action of sulfuric acid and which has become spent and comparatively ineffective for further use as a catalyst in the alkylation of hydrocarbons. The reaction is carried out in the liquid phase.

U.S.P. 2,375,694. Process of Refining Hydrocarbon Oil for the Purpose of Removing Metal Ions. H. G. Schutze to Standard Oil Development Company.

Small amounts of metal ions remaining in hydrocarbon fluids from such treatments as copper sweetening are removed by an ion-exchange treatment with an acid mass, prepared by coking an acid sludge followed by treament of the sludge with concentrated acid at high temperatures.

U.S.P. 2,376,051. Removal of Light Hydrocarbons from Admixture with Hydrogen Fluoride. K. H. Hachmuth to Phillips Petroleum Company.

Light hydrocarbons are removed from admixture with hydrogen fluoride by forming an acid layer and a hydrocarbon layer in a first settling zone. The acid layer is contacted with a heavy hydrocarbon liquid under conditions such that two liquid phases are formed in a second settling zone and relatively light hydracarbons are selectively extracted from said acid layer by the heavy hydrocarbon liquid.

U.S.P. 2,376,558. Production of High-Octone Fuels. G. H. Short and G. G. Oberfell to Phillips Petroleum Company.

The lead susceptibility of fuels, produced by the polymerization of normally-gaseous olefins and subsequent hydrogenation, is frequently reduced by the presence of oxygenated compounds such as alcohols which may be formed by the hydration of olefins. Polymers are therefore passed at 550-650° F. over a solid granular dehydration catalyst prior to hydrogenation in order to remove such impurities.

U.S.P. 2,378,969. Purification Process. G. C. Bailey and J. A. Reid to Phillips Petroleum Company.

Impurities are removed from olefins prior to hydrogenation or other catalytic treatment by contacting the olefins at

You have to know PIPING *to make* PIPE HANGERS

A working knowledge of springs, levers and other mechanical devices is not enough to develop pipe hangers to meet the varied requirements caused by expansion, contraction, pressure, vibration and load.

The designing and production of PIPE HANGERS calls for a thorough knowledge of piping and piping systems . . . the kind of knowledge Grinnell has acquired as a result of 95 years of piping experience. Because of this background, Grinnell is able to offer standard and special-purpose hangers to meet every conceivable requirement in piping. GRINNELL COMPANY OF CANADA, LTD. Toronto–Montreal–Winnipeg–Vancouver.

GRINNELL CONSTANT-SUPPORT HANGERS . . . the *ONLY* CONSTANT-SUPPORT PIPE HANGERS. Weight transfer stresses are completely eliminated throughout the entire range of vertical movement.

GRINNELL PRE-ENGINEERED SPRING HANGERS . . . For flexibly supported piping, where constant-support is not required, Grinnell Spring Hangers allow less variation in supporting force.

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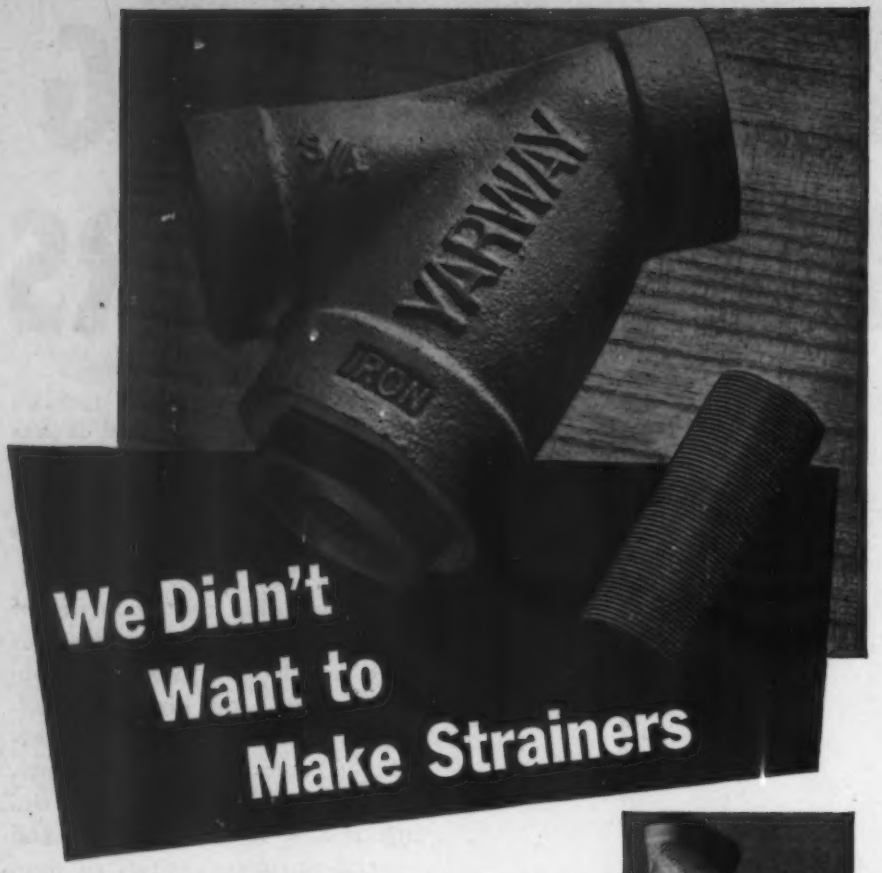
WHENEVER **PIPING** IS INVOLVED

GRINNELL PIPE HANGERS AND SUPPORTS . . . A complete line of adjustable hangers and supports engineered to meet all requirements.



We Didn't Want to Make Strainers

BUT we needed them for use with Yarway Steam Equipment and couldn't find any to suit us.

So we designed the *YARWAY Strainer.*

Apparently a lot of other people were having "Strainer trouble" because, without a line of advertising, the Yarway Strainers *purchased* in a few years now number *many thousands.*

Why don't you look into this better Strainer for your money? Buy one from your supply house (over 100 Mill Supply Houses now have them).

See its protection against corrosion—*cadmium plating inside and out.*

Examine its *high grade Monel woven wire screen* that stops dirt—lets condensate or other fluids flow freely.

Notice the removeable blow-off bushing. Screen and bushing come out together—go back together, *automatically aligning.*

Six standard sizes from ½" to 2" for pressures to 600 lb.

See your Mill Supply House or write for Bulletin S-200

YARNALL-WARING COMPANY
128 Mermaid Ave. PHILADELPHIA 18, PA.

YARWAY STRAINERS

50-150° C. in the absence of free hydrogen with a catalyst consisting of nickel on kieselguhr.

U.S.P. 2,380,561. Refining Aromatic Distillates. F. T. Wadsworth to Pan American Refining Company.

The color of refined toluene from the acid-treating operation can be stabilized to a remarkable degree by the addition of a very small amount of maleic anhydride. The same treatment will restore the color of already storage-deteriorated toluene. The amounts of maleic anhydride employed vary from 0.005-0.1 percent.

U.S.P. 2,381,293. Process for Decolorizing Hydrocarbon Oil. W. A. LaLande, Jr., to Attapulgus Clay Company.

The decolorizing effect of fuller's earth for hydrocarbon oils is markedly increased by extruding the fuller's earth in a plastic state at elevated pressure and in admixture with from 0.1-1.75 percent by weight, based upon volatile-matter-free earth, of a water-soluble alkaline agent. The mixture is dried, reduced to granular size and calcined.

U.S.P. 2,382,144. Gelatination of Hydrocarbon Distillates. W. K. Griesinger to The Atlantic Refining Company.

Alkali metal peroleum sulfonates are used as gelling agents for the gelatination of hydrocarbons to produce solidified fuels.

U.S.P. 2,382,505, 2,382,506. Olefin Recovery Process. W. A. Schulze to Phillips Petroleum Company.

Olefins are removed from a predominantly aliphatic fraction by treating the hydrocarbons at 300-450° F. and 50-500° psi with benzene in the presence of an alkylation catalyst such as silica gel promoted with a minor amount of alumina. The olefin-denuded aliphatic hydrocarbons are stripped from the aromatics which are fractionated to remove benzene. The alkyl benzenes are cracked over clays, bauxite or synthetic cracking catalyst at 700-1000° F. to recover olefins and recycle benzene.

U.S.P. 2,384,311. Chemical Process. K. K. Kearby to Jasco, Inc.

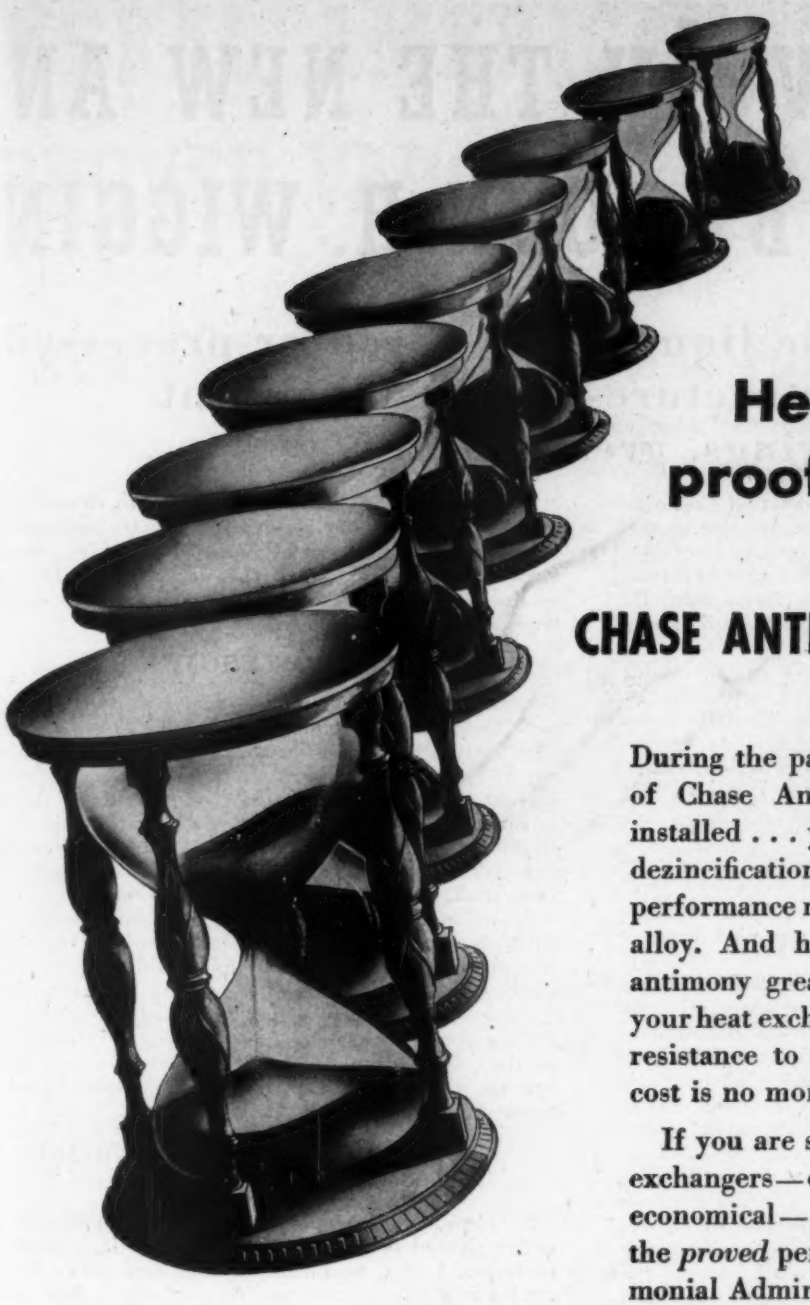
A hydrocarbon is separated from a mixture of hydrocarbons containing the same by countercurrent fluid contact with an adsorbent and steam stripping of the hydrocarbon from the adsorbent in a stripping zone. A portion of the desired hydrocarbon is refluxed to the adsorption zone at a point beyond that at which the countercurrent flow takes place.

U.S.P. 2,384,905. Method of Producing White Oils. C. M. Floyd and J. Fram to Standard Oil Development Company.

Predominantly paraffinc oil is treated in a multitude of steps with a total of about 200-300 pounds of 85-98 percent sulfuric acid per barrel of oil at 160° F. The acid sludge is removed after each step, the oil finally dried by passing gas through it at 250-300° F. and the treated oil contacted with clay for not less than 30 minutes at 300° F.

U.S.P. 2,385,431. Process of Refining Hydrocarbon Oil With Metallic Sodium. R. S. Vose to Sun Oil Company.

Undesirable constituents are removed from hydrocarbons by contacting liquid



Here's convincing proof of service life

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CHASE ANTIMONIAL ADMIRALTY*

During the past ten years, *millions* of pounds of Chase Antimonial Admiralty have been installed . . . yet not one service failure from dezincification has been reported to mar the performance record of this heat exchanger tube alloy. And here's another thing: while the antimony greatly reduces the yearly costs of your heat exchanger tubes (due to the increased resistance to dezincification), the initial tube cost is no more than for plain Admiralty.

If you are seeking a superior alloy for heat exchangers—one that will be both reliable and economical—you need look no farther than the *proved* performance record of Chase Antimonial Admiralty.

KEEP THIS IN MIND — Chase Antimonial Admiralty offers you outstanding service life since it is highly resistant to dezincification and costs no more than plain Admiralty.

For details phone your nearest Chase Warehouse or Service Office.

*U. S. Pat. No. 2,061,931

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CHASE BRASS & COPPER CO.

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ALBANY† ATLANTA† BALTIMORE BOSTON CHICAGO CINCINNATI CLEVELAND DETROIT HOUSTON INDIANAPOLIS KANSAS CITY, MO.† LOS ANGELES MILWAUKEE

MINNEAPOLIS NEWARK NEW ORLEANS NEW YORK PHILADELPHIA PITTSBURGH PROVIDENCE ROCHESTER† SAN FRANCISCO SEATTLE ST. LOUIS WASHINGTON†

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This is the Chase Network—handiest way to buy brass

Exclusively THE NEW AND PATENTED BY JOHN H. WIGGINS

Wherever volatile liquids are stored or processed, Wiggins structures assure important savings, greater safety!

For years General American Transportation Corporation has been out in front in rendering service to the petroleum industry. Now General American has fortified its leadership by acquiring the sole rights to manufacture and sell, as exclusive licensee under John H. Wiggins patents, the new and improved Wiggins vapor-saving structures.

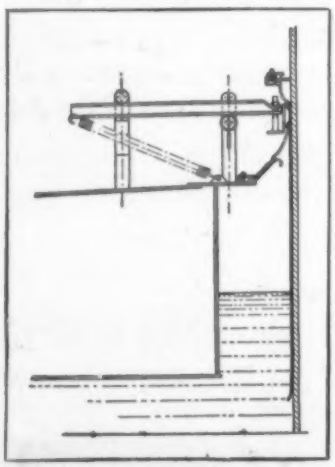
The new Wiggins Pontoon Roof, featuring many improvements, is typical of the many new and improved Wiggins structures manufactured by the General American Plate and Welding division. It can help you solve your evaporation-loss problems, safely and surely, because it floats directly on the surface of the liquid, stops evaporation loss, and reduces fire hazard.

COST AMORTIZED QUICKLY IN SAVINGS

Here are some of the losses which are prevented, eliminated, or reduced by the new and improved Wiggins Pontoon Roof, illustrated at left:

BREATHING LOSSES . . . Whenever increasing temperature causes expansion in vapor space of tanks having a fixed roof, vapor is vented to atmosphere. Losses resulting from this daily exhalation of vapor are called breathing losses—an expensive waste which is stopped by "improved" Wiggins Pontoon Roofs because of their elimination of *active* vapor space.

FILLING LOSSES . . . With fixed roof tanks, vapor is displaced through roof vents during filling. When a tank equipped with an "improved" Wiggins Pontoon Roof is filled, no vapor is displaced because roof floats on the liquid surface. No filling loss occurs from the small space between roof and tank shell because the volume of this space remains constant even when roof is rising.



Section of new and improved Wiggins Pontoon Roof seal showing details of shoes used with butt welded tank shells. A continuous strip of flexible seal material forms wind-proof connection between top of shoe and roof of deck.

BOILING LOSSES . . . In addition to eliminating all filling loss and reducing breathing loss to a minimum, the "improved" Wiggins Pontoon Roof traps vapor, formed by boiling, under the deck. This vapor is retained under roof until recondensed by cooler temperatures.

PROTECTION FROM FIRE

By eliminating the conditions which permit contents of tank to burn, the "improved" Wiggins Pontoon Roof effectively helps prevent fire. Liquid beneath deck cannot become ignited because there is insufficient oxygen present to support combustion. And since the tank has an open top, there is no danger of an explosive mixture forming above roof. The only point where a fire might conceivably burn is in space between rim of roof and tank shell. This space, however, is sealed with a fire-resistant material consisting largely of asbestos woven with glass, and repeated tests have proved that even if seal becomes damaged, a fire in this area can be easily extinguished, even after burning for some time. A complete discussion of the fire retardant features of the unimproved Wiggins Pontoon Roof may be obtained in the "Report on Floating Roof for Vertical Steel Storage Tanks" issued by the Underwriters' Laboratories, Chicago, Ill.

WIDE APPLICATION TO NEW OR EXISTING TANKS

The "improved" Wiggins Pontoon Roof is applicable to either riveted or welded tanks of all 15 ft. diameters or larger. It can be furnished with new tanks or installed in existing tanks, and for this reason finds wide application at pipeline stations, refineries, bulk stations, marine terminals and chemical plants. A sound investment for any large tank storing crude oil or gasoline, the "improved" Wiggins Pontoon Roof is also recommended for service on working tanks, blending tanks and tanks containing corrosive oils.

For complete information regarding the "improved" Wiggins Pontoon Roof or other "improved" Wiggins structures and their possible application to the solution of your special problems, get in touch with our nearest office.

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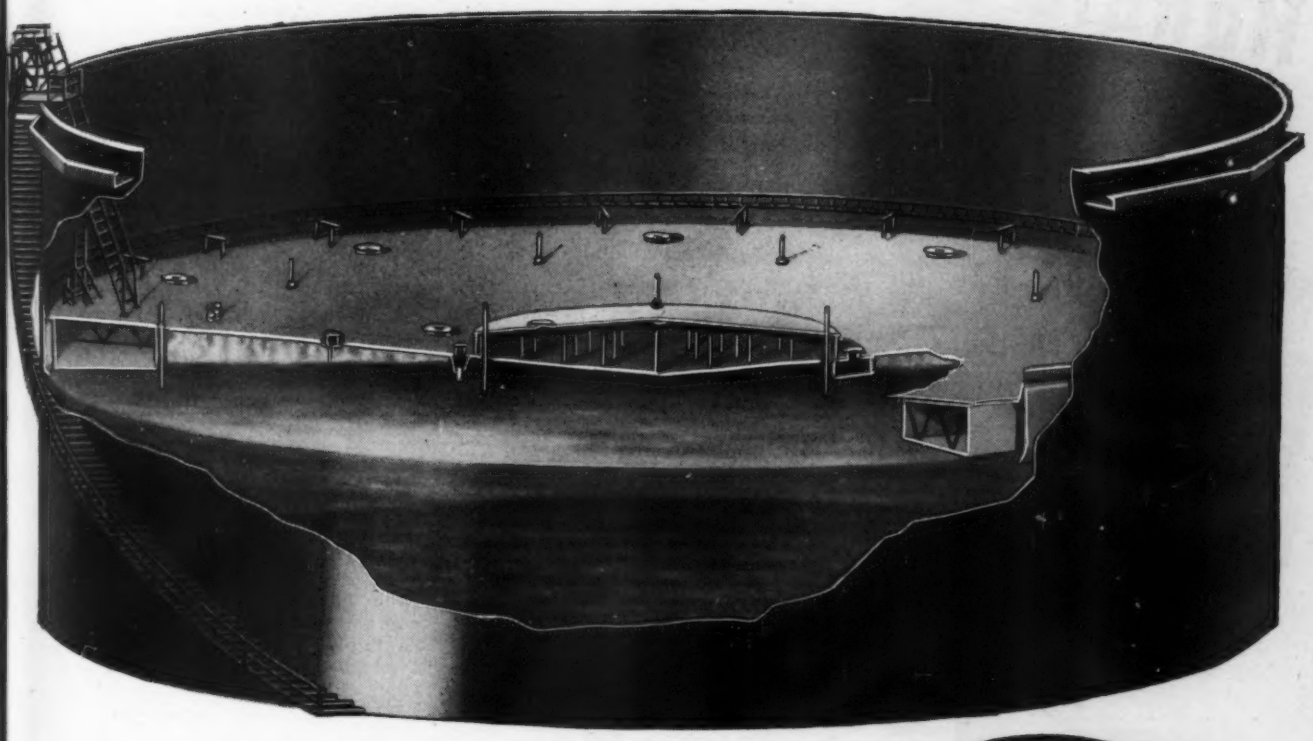

CUT-AWAY VIEW of an improved Wiggins Pontoon Roof installed on butt welded tank. Note how roof floats directly on liquid, blanketing surface at all levels, thus stops evaporation loss and reduces fire hazard by eliminating active vapor space in tank. Note covered center pontoon which prevents evaporation of the liquid due to the heat of the sun, and new improved ladder which provides safe, easy access to deck from top of tank. Upper end of ladder rides around an ingenious "ferris wheel" and lower end is pivoted on peripheral pontoon. Handrails are provided for safety.

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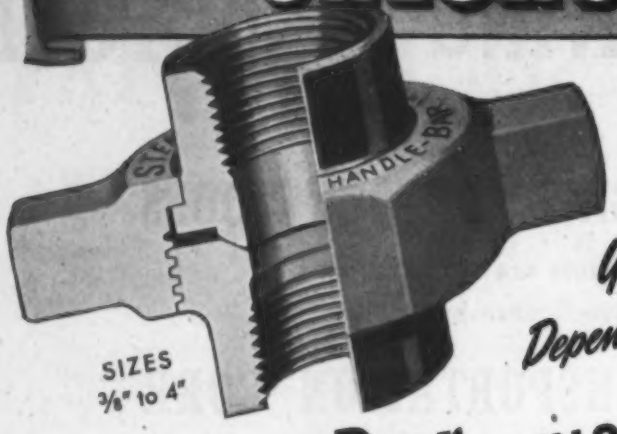

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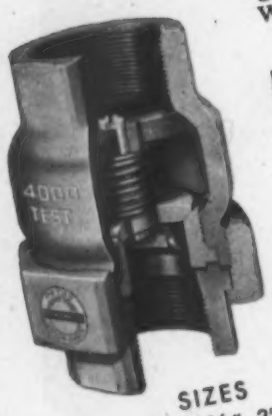

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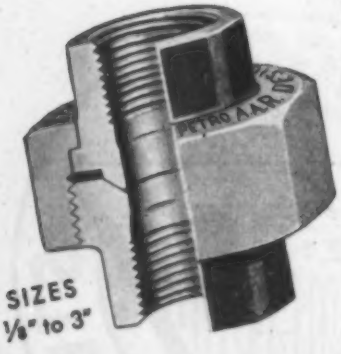

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hydrocarbons with finely dispersed metallic sodium in amounts substantially in excess of the amount chemically consumed in the reaction at a temperature above the melting point of sodium but below cracking temperature. A sludge which is nearly solid at atmospheric temperature is formed. The reaction mixture is passed over a magnetized surface, which removes excess sodium, to a separation zone where raffinate is separated from sludge.

U.S.P. 2,386,055. Separation of Tertiary Olefins from Hydrocarbon Mixtures. H. O. Mottern to Standard Oil Development Company.

Tertiary-base olefins are condensed with formaldehyde, its homologues or other aldehydes such as furfuraldehyde or benzaldehyde in the presence of sulfuric acid catalyst at 0-100° C. The tertiary olefin reacts faster than primary or secondary olefin, so that if stochiometrical amounts are present a complete separation can be obtained.

U.S.P. 2,386,200. Recovery of Diolefins. H. E. Drennan to Phillips Petroleum Company.

Butadiene is recovered from a hydrocarbon fluid by contact with cuprous chloride at 40-80° F. An insoluble addition compound is formed, removed and decomposed at 120-210° F. by contacting it with a stream of hot pure butadiene.

U.S.P. 2,386,272. Process for the Stabilization of Unsaturated Hydrocarbons. W. A. Schulze to Phillips Petroleum Company.

Dissolved copper compounds contained in substantially pure butadiene which has been recovered by decomposition of cuprous chloride-butadiene complexes, are removed by precipitation with hydrogen sulfide or alkyl mercaptans.

U.S.P. 2,386,300. Process for Treating Hydrocarbons. H. E. Drennan and W. A. Schulze to Phillips Petroleum Company.

Diolefins are separated from hydrocarbon mixtures by dissolving cuprous chloride in an olefin-containing solvent, contacting the solvent with the diolefin-containing mixture, precipitating insoluble addition compounds of cuprous chloride and diolefin, and separating these compounds from the solvent in which new cuprous chloride is dissolved. The reaction is carried out at about 35° F.

U.S.P. 2,386,350, 2,386,351, 2,386,352, 2,386,353, 2,386,354. Treatment of Hydrocarbons. W. A. Schulze to Phillips Petroleum Company.

A butane-butene stock is catalytically dehydrogenated and the condensed liquid passed over an adsorbent carrier impregnated with cuprous chloride. Butadiene is absorbed and the diolefin-free residuum is passed to a mixing chamber for contact with a solution of 5 percent sodium sulfide and 5 percent sodium hydroxide. The hydrocarbon effluent, after settling, is free of dissolved copper and can be recycled to the dehydrogenation zone.

U.S.P. 2,386,379. Diolefin Recovery. I. L. Wolk to Phillips Petroleum Company.

Hot cuprous halide-containing reagent, from which the diolefin has been lib-

erated in an immediately preceding step, is contacted with a relatively cool gaseous medium to effect partial cooling of the reagent and simultaneous partial heating of the gaseous medium. A relatively cool body containing the cuprous halide-diolefin complex is then contacted with the resulting partially heated gaseous medium whereby the complex is preheated preliminary to desorption and the gaseous medium is simultaneously cooled. The thus partially heated complex is then further heated to decomposition temperature to liberate the diolefin combined therein.

U.S.P. 2,386,734. Method for Recovery of Diolefins. I. L. Wolk to Phillips Petroleum Company.

Butadiene is recovered from gas mixtures by contacting with cuprous chloride, preheating the butadiene-cuprous chloride complex in a hot gas stream containing butadiene, decomposing the complex in an inert hot gas and using the hot gas-butadiene mixture to preheat more butadiene-cuprous chloride complex. Butadiene is separated from the inert gas by conventional methods.

U.S.P. 2,386,769. Method for Separating Hydrocarbons and Making Mercaptans. D. E. Badertscher, H. L. Coonradt and D. J. Crowley to Socony-Vacuum Oil Company.

The method of selectively separating a tertiary-base olefin selected from the group consisting of isobutylene, trimethyl ethylene and unsymmetrical methyl ethyl ethylene from a hydrocarbon mixture containing said tertiary-base olefin, normal olefins, secondary olefins and saturated hydrocarbons, which comprises: admixing said hydrocarbon mixture with hydrogen sulfide; passing the reaction mixture thus formed in the vapor phase through a reaction zone containing a catalyst selected from the group consisting of acids and thioacids of phosphorus and their anhydrides and thioanhydrides, regulating the flow of said reaction mixture through said reaction zone to provide a very breif contact time therein and maintaining the temperature of said reaction mixture therein between about 60° C. and about 90° C., whereby said tertiary-base olefin is converted to the corresponding tertiary mercaptan; and separating said mercaptan from the reaction product so obtained.

U.S.P. 2,386,927. Process for Separating Diolefins. J. H. Boyd, Jr., to Phillips Petroleum Company.

Aliphatic conjugated diolefins are extracted from hydrocarbon mixtures with a selective solvent consisting of an alkyl-N-substituted lower fatty acid amide such as dimethyl formamide.

YPFB of Bolivia Plans Refinery at Cochabamba

YPFB, the Bolivian semi-state entity in charge of petroleum production, is considering the possibility of establishing an oil refinery at Cochabamba at a cost of $5,000,000.

Plan 1946 Exposition of Chemical Industries

Exposition of Chemical Industries has announced plans for its twentieth exposition to be held in Grand Central Palace, New York, February 25 to March 2.

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The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by The Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical and Chemical Data

Method of Calculating the Properties of Hydrocarbons and Its Application to the Refractive Indexes, Densities, and Boiling Points of the Paraffin and Monoolefin Hydrocarbons. W. J. TAYLOR, J. M. PIGNOCCO, AND F. D. ROSSINI. *J. Res. Natl. Bur. Standards* 34 (1945) pp. 413-34 (Res. Paper No. 1651).

A method is developed for calculating the properties of hydrocarbons based on the method of least squares. In the method allowance is made for the contributions from component parts of the molecule and from the interactions of adjacent component parts. For the paraffin hydrocarbons the calculations are based on differences in the values of the property between a given normal paraffin and its isomers. The procedure is applied to 33 paraffins from C_5-C_8 and gives an average deviation of calculated from experimental values of ± 0.00074 g./ml. in d., ± 0.00042 in refractive index, and $\pm 0.55°$ in boiling point. Calculations for the monoolefins are made in terms of the difference in value of the property between a given monoolefin and the corresponding paraffin with the same carbon skeleton. Fifty-eight monoolefins from C_5-C_7 were included.

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, 33rd, Federal and Dearborn Streets, Chicago 16, Illinois, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only one gram quantities, please inform the Registry.

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2-Butyne
1-Pentyne
2-Pentyne
3-Methyl-1-butyne
1-Penten-4-yne
Methyl, dimethyl, trimethyl, or ethyl anthracenes
Methyl, dimethyl, trimethyl, or ethyl phenanthrenes
Methyl, dimethyl, trimethyl, or ethyl diphenyls
Methyl, dimethyl, trimethyl, or ethyl acenaphthenes
Methyl, dimethyl, trimethyl, or ethyl fluorenes
Methyl, dimethyl, trimethyl, or ethyl tetralins
O-Methyl isourea
ortho and meta Cymene
Anthraquinone beta sulfonic acid
Melissyl alcohol
Phytyl alcohol or bromide
Isopropyl isoamyl acetic acid
Vinyl cyclopropane
Cyclobutane
Acrylyl chloride or bromide
2,5-Dibrom valeric acid and esters
Brom malonic acid

Empirical Heat Capacity Equations of Various Gases. H. M. SPENCER. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 1859-60.

New and more satisfactory values of the thermodynamic functions in the hypothetical ideal gaseous state have been derived from spectroscopic data. Those for the normal paraffins are based on more adequate data. The older data for seven of these substances have been corrected to correspond to the use of the new values of the fundamental constants, and equations are presented for all of them except hydrogen, for which the old equation represents the new values as well as a new equation. Data for the paraffins, as well as some aromatics, olefins, and other substances are presented in detail in tabular form.

Nomographs for Enthalpies of Pure Hydrocarbons and Their Mixtures. E. G. SCHEIBEL AND F. J. JENNY. *Ind. & Eng. Chem.* **37** (1945) pp. 990-95.

Three nomographs are given that present the vapor and liquid enthalpies of individual hydrocarbons and hydrocarbon solutions. The first gives the enthalpies of normal saturated paraffins from methane to n-octane, and the construction is such that at a single setting the enthalpy can be found for all the liquid components at a given temperature and of all the components in the vapor at a given temperature and pressure. The second nomograph presents the liquid and vapor enthalpies of solutions of light hydrocarbons based on the average molecular weight of the mixture. Joule-Thomson effects determined from this nomograph agree with data on hydrocarbon mixtures within the limits of precision of the nomograph and within the accuracy of the data. The third nomograph gives the liquid and vapor enthalpies of the heavier petroleum fractions. It is based on a correlation of the properties of the various fractions of an oil with a characterization factor of 11.8. The nomograph is accurate within the limits of reliability of the basic correlation.

Vapor-Liquid Equilibria for Natural Gas-Crude Oil Mixtures. C. H. ROLAND. *Ind. & Eng. Chem.* **37** (1945) pp. 930-36.

Equilibrium constants and related phase data were obtained for a mixture of League City natural gas and Billings crude oil for pressures in the range from 1000 to 10,000 pounds per square inch and temperatures from 120° to 200° F. Data were also obtained for other mixtures of oil and gas, and were compared to the data for the fixed-composition mixture. The effect of composition upon the equilibria was studied, and through two experiments in which the composition was varied by removal from the system of a liquid phase at a higher pressure the effect of a particular composition change was determined. The composition change affected the component characteristic of the heptanes and heavier component but not the equilibrium constants. Colored hydrocarbon fractions were found to be present in the vapor phase at high pressures. The data secured in the work are presented in considerable detail in five tables and seven figures. The literature of phase equilibria for natural gas and crude oil mixtures is briefly reviewed, and five references are given.

The C-C Valency Vibrations of Organic Molecules. L. KELLNER. *Trans. Faraday Soc.* **41** (1945) pp. 217-23.

General formulas are derived for the valency vibrations of normal chains of CH_2 groups, of isomeric structures, and of cyclic molecules. The carbon-carbon valency frequencies are calculated and compared with observed spectra for the n-aliphatic hydrocarbons from C_3 to C_{10}, for the saturated ring hydrocarbons C_5 to C_8, and for various hydrocarbons with side chains in different positions. The agreement between the calculated and observed values is such that it is concluded that the interaction between bending and stretching vibrations is only a second-order effect.

Physical Properties of Thiophene. F. S. FAWCETT AND H. E. RASMUSSEN. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 1705-09.

A sample of thiophene large enough to assure good working quantities was purified by distillation and crystallization to give a product that froze at a temperature constant to 0.01° C. Freezing

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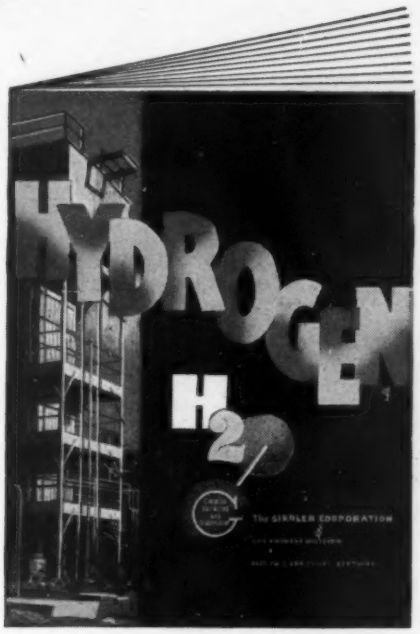

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point, boiling point over the range 500-900 mm., refractive index and density and viscosity at 20, 25, and 30° C., and specific dispersion at 20° C. were determined. The method of physical purification is described in detail. A sample was also prepared by chemical purification and the properties found to agree with those of the sample that was physically purified. The data secured in the work are presented in tabular form and compared to the data from the literature. The system thiophene-benzene was also studied, and the refractive index, density, viscosity, and freezing point were studied as a function of composition. The data so obtained are presented in tabular and graphical form.

Chemical Compositions and Reactions

The Mechanism of the Alkylation of Paraffins. L. SCHMERLING. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 1778-83.

The catalytic alkylation of isoparaffins with olefins has been studied extensively for a decade. Several reaction mechanisms, none of which could be satisfactory, have been proposed during this period. The author presents what he regards as a mechanism that has none of the objectionable features of previous ones, and that gives a clearer picture of what occurs during alkylation. A chain mechanism is proposed that involves the following reactions: (1) conversion of the isoparaffin to a t-alkyl ester; (2) addition of the t-alkyl ester to the olefin to yield an ester of higher molecular weight; (3) reaction of the ester of higher molecular weight with the isoparaffin to yield the observed paraffin product and a new molecule of the t-alkyl ester. The t-alkyl ester formed in the third step reacts with olefin as in the second step and the cycle is repeated. The evidence in support of this proposed mechanism is presented.

Reaction of Methylcyclopentane with Olefins in the Presence of Sulfuric Acid and Hydrogen Fluoride Catalysts. H. PINES AND V. N. IPATIEFF. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 1631-38.

The reaction of methylcyclopentane with olefins in the presence of sulfuric acid and of hydrogen fluoride was studied. n-Butenes, isobutylene, 2-pentene, 3-methyl-1-butene, and a mixture of 2,4,4-trimethyl-1-pentene and 2,4,4-trimethyl-2-pentene were used in the work. The reaction involves: (a) addition of methylcyclopentane to olefins accompanied by ring expansion and migration of alkyl groups within the ring, (b) hydrogen disproportionation, (c) isomerization of straight chain olefins to isoolefins followed by hydrogenation, (d) reaction of partially dehydrogenated naphthene with cycloolefins or with saturated cyclic hydrocarbons to form polycyclic olefins or polycyclic saturated hydrocarbons, (e) depolymerization and/or depolyalkylation. The reaction of methylcyclopentane with n-butenes in the presence of sulfuric acid gives high yields of 1,3,5-dimethylethyl- and 1,3-dimethyl-4-ethylcyclohexane. The mechanism of alkylation is discussed.

Alkylation of Isoparaffins by Olefins in Presence of Hydrogen Fluoride. C. B. LINN AND A. V. GROSSE. *Ind. & Eng. Chem.* **37** (1945) pp. 924-9.

Hydrogen fluoride has a number of advantages that recommend it for use as a catalyst in the alkylation of isoparaffins with olefins. It is a stable compound and can be subjected to high temperatures and pressures without decomposition. Many of its organic compounds decompose either by heat alone or in the presence of catalysts to regenerate hydrogen fluoride. Substantially all of the combined fluorine in the alkylation reaction products is recoverable as hydrogen fluoride. It is stable both toward oxidizing and reducing reagents. The organically bound fluorine in the paraffinic reaction product is usually less than 0.01%, and this compound is readily removed by passing the alkylate over a catalyst such as calcium fluoride or aluminum fluoride at a temperature in the neighborhood of 100° C. Alkylation was studied in the laboratory, both by continuous and batch methods, and in apparatus of simple design. The effects of temperature, contact time, ratio of isoparaffin to olefin, and catalyst concentration in water were studied. Isobutane and isopentane were used, along with the olefins, propene, isobutylene, 1-butene, and 2-butene. Also the production of alkylate from a butane-butene mixture was studied. The results of the work are presented in tabular and graphical form. A bibliography of 25 references is included.

Catalytic Cracking of Pure Hydrocarbons. B. S. GREENSFELDER AND H. H. VOGE. *Ind. & Eng. Chem.* **37** (1945) pp. 983-88.

The cracking of seven aliphatic olefins, two diolefins, two cyclic olefins, and two aromatic olefins was studied using a silica-zirconia-alumina catalyst in the temperature range 350-500° C. It was found that aliphatic monoolefins were isomerized, cracked, saturated, and formed higher-boiling materials and coke. Diolefins and aromatic olefins were extensively saturated and transformed to higher-boiling materials and coke. Catalytic and thermal cracking of olefins at 400-500° C. are compared. The catalyzed reactions, which are 1000 to 10,000 times as fast as the uncatalyzed, yield larger fragments, involve more isomerization, and lead to greater saturation of the final product. The data secured in the course of the work are presented in seven tables and one figure. A bibliography of 17 references is included.

The Addition of Fluorine to Double Bonds. A. L. HENNE AND T. P. WAALKES. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 1639-40.

The addition of fluorine to double bonds is impractical because of the large amount of heat evolved which decomposes the organic material. The authors present a new procedure by which addition of fluorine to an olefinic double bond is achieved by interaction of lead dioxide with hydrogen fluoride in the olefin that is to receive the fluorine. The reaction produces what the authors term nascent lead tetrafluoride, which compound decomposes into lead difluoride and a mole of fluorine that is accepted by the olefinic double bond. The reaction was tested with seven olefin bond-

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containing compounds and the results of the reaction are presented in tabular form showing products and yields.

The Addition of Phosphorus Trichloride to Olefins. M. S. KHARASCH, E. V. JENSEN, AND W. H. URRY. *Jour. Amer. Chem. Soc.* **67** (1945) pp. 1864-5.

The authors note that no satisfactory method has been described in the literature for the preparation of phosphorus compounds of the type $RPCl_2$, where R is an aliphatic radical. It was found that if an unsaturated compound is heated with an excess of phosphorus trichloride, in the presence of a small quantity of a diacyl peroxide, addition of the phosphorus trichloride to the double or triple bond takes place readily. A description is given of the experimental details of the treatment of octene-1 with phosphorus trichloride to give the compound $C_8H_{16}Cl_2P$.

Manufacture: Processes and Plant

Two-Component Equilibrium Curves for Multicomponent Fractionation. F. J. JENNY AND M. J. CICALESE. *Ind. & Eng. Chem.* **37** (1945) pp. 156-59.

A method of ploting equilibrium curves for multicomponent systems is based on the use of equilibrium values for the "light key component and lighter." This procedure is similar to the McCabe-Thiele method for two-component systems. The authors state that it has been in use for over five years, and its application to the solution of industrial problems has been found useful and time saving. Illustrative examples are given. The proposed method of applying the two-component structure presupposes that a complete solution is available for a specific problem and that another solution is desired in which conditions are not greatly changed from those of the original problem.

Analysis Determines Control Variables for Distillation Systems. C. W. PERRY. *Chem. & Met. Engr.* **52,** No. 9 (1945) pp. 108-12.

The author presents a method of analyzing process variables developed to aid in the application of automatic control to continuous distillation systems. Minimum control requirements can be determined by this method without the use of engineering approximations. The fundamental basis of the method is presented and variables are classified. Control systems for rectifying columns, stabilizers, and alcohol stills are considered in some detail. A bibliography of 11 references on the subject is included.

Occurrence of Metastable States of Liquid and Vapor. R. F. LARSON. *Ind. & Eng. Chem.* **37** (1945) pp. 1010-16.

The author advances a thermodynamic theory for the requirements and mechanism of bubble formation in a heated liquid. Trial calculations using estimated thermodynamic properties of superheated water indicate that the nucleus bubble in the transformation state consists of a single molecule. The general theory is extended to cover condensing water vapor. The literature is reviewed for supporting evidence. The similarity between the supposed action of the ebullator and a catalyst is suggested.

Application of Automatic Controllers to Heat Exchangers. J. L. MORE, F. J. QUAIL, AND J. W. BAIN. *Ind. & Eng. Chem.* **37** (1945) pp. 912-16.

The authors review the methods used by Ziegler and Nichols for finding the optimum settings for temperature controllers. Applied to a heat exchanger, the coefficient u to be used in the sensitivity, $S = u/R_1L_2$ was determined by the reaction or response curve method. The work was carried further by calculating the value of the capacitances of the exchanger that contributes to the form of the response curve and by graphically reconstructing this curve. Coefficient u found by this method compares favorably with the value determined experimentally.

Isopentane Produced by Liquid-Phase Isomerization. L. S. GALSTAUN. *Chem. & Met. Engr.* **52** No. 9 (1945) pp. 109-11.

Isopentane, which has been so vitally important to our high-octane aviation gasoline program, has definite promise as an ingredient in postwar premium motor fuels. Isomerization of low-octane pentanes from natural gasoline may represent one way of up-grading these paraffins into more valuable gasoline components. The Tide Water Associated Oil Company has operated at its Avon, California, refinery, a liquid-phase pentane isomerization plant of the Shell type. The plant is essentially similar to the liquid-phase butane isomerizers using antimony trichloride as a catalyst carrier. This plant, the first commercial plant of its type, converts normal pentane to isopentane. A yield of 50-60 liquid volume percent isopentane is obtained on a once-through basis. Side reactions are normally so slight that about 97 percent yield can be obtained by recycling unconverted normal pentane. The flow is continuous both as to hydrocarbon feed and make-up of catalyst. The active catalyst employed is anhydrous aluminum chloride, together with about 5 mol percent of anhydrous hydrogen chloride (on the basis of hydrocarbon feed). The aluminum chloride is carried as a solution in molten anhydrous antimony trichloride. The process is described in some detail, as well as catalyst removal, process control, and corrosion factors. A flowsheet is given.

Redwood Products as Inhibitors of Oxidation in Petroleum Hydrocarbons. H. F. LEWIS, M. A. BUCHANAN, D. FROMMULLER, AND E. F. KURTH. *Ind. & Eng. Chem.* **37** (1945) pp. 988-90.

Redwood tannin preparations were found to be effective inhibitors of the oxidation of mineral oil. Redwood chips were extracted with alcohol and the extract concentrated and steam-distilled, diluted with water, saturated to a thick syrup, and extracted with ethyl acetate. Two "tannin" fractions were obtained, one soluble and the other insoluble in ethyl acetate. The active inhibiting principles are present in the ethyl acetate-

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soluble part of the tannin fraction and apparently are absent in the ethyl acetate-insoluble part. Redwood tars were also prepared by the destructive distillation of redwood. The ether-soluble tar and the phenol fraction obtained by a vacuum destructive distillation of redwood phlobaphene were both found to be effective inhibitors.

Alcohol Economics Will Determine Future Production Processes. R. D. TOUSLEY. *Chem. & Met. Engr.* **52,** No. 9 (1945) pp. 120-23.

The time is drawing close when orthodox economic factors will determine which of the newer raw materials and processes will be used in the manufacture of industrial alcohol. With ethylene available at 13 cents per pound, the cost of synthetic alcohol will be 13 to 14 cents per gallon. If ethylene can be made available at 2 cents per pound, the cost of synthetic alcohol would be approximately 10 cents per gallon. With molasses available at 5 cents per gallon, the cost of molasses alcohol will be 16 cents. With corn available at 45 cents per bushel, the cost of grain alcohol would be 20½ to 23½ cents per gallon. Alcohol from waste sulphite liquid can probably be made from 16 to 19 cents per gallon. Alcohol from wood waste can be made for 20½ to 22 cents per gallon. If ethylene can be produced for 2 cents a pound, molasses will have to sell for 3 cents a gallon in order to compete.

Acetylene Industry in Wartime Germany. R. L. HASCHE. *Chem. & Met. Engr.* **52,** No. 9 (1945) pp. 116-19.

The development of a large acetylene industry was forced upon Germany by the lack of petroleum reserves and carbohydrate material. The article presents the statistics of the industry of acetylene production from calcium carbide and by the electric arc and also data on a large number of derivatives and synthetic products made from acetylene. Large amounts of acetylene went into the manufacture of butadiene. Large quantities of acetylene were converted to ethylene by catalytic hydrogenation. The ethylene was used for the manufacture of ethyl benzene or styrene, and also ethylene oxide and its derivatives. Acetylene was used in large quantity for the production of vinyl compounds for thermoplastics, adhesives, lacquers, and additives for lubricating oil. The article presents 7 tables showing the production and consumption of calcium carbide, the production of solvents from acetylene, the production of ethylene and derivatives, manufacturing capacity for plastics synthetic rubber and fiber, and the quantity of plastics produced from acetylene.

Products: Properties and Utilization

Stability of Fuel Oil. W. E. J. BROOM. *Jour. Inst. Petr.* **31** (1945) pp. 347-52.

A brief account is given of the work of the Institute of Petroleum's Panel for the Study of the Stability of Fuel Oil. A report on studies of storage stability as measured by the Sediment by Hot Filtration test is given. It is concluded that more work must be done before the method can be used as a standard method or even a tentative standard. The Xylene Equivalent test for determination of stability on blending was studied. The results indicate that much further work is needed before the test can be considered as satisfactory. The stability of oils to heat treatment was examined using the U. S. Navy Heater test. The apparatus is described and the results of the test of eight oils in three laboratories are given. There was excellent agreement between the results of the three laboratories.

Schmierstoffe und Maschinenschmierung. E. H. KADMER. *Verlag von Gebruder Borntraeger,* Berlin - Zehlendorf - West, Germany, 1944. 479 pp.

The first edition of this book was published in 1939 and was followed by a second edition in 1941. In 1944 the second edition was made available to readers in this country through a reprint authorized by the Alien Property Custodian. The first two chapters deal with the composition and manufacture of oils. The third chapter considers at length the characteristic values of oils, including density, viscosity, color and fluorescence, pour point, flash point, fire point, refraction and dispersion, optical and dielectric properties, specific heat and thermal conductivity, mean molecular weight, chemical analysis and C:H ratio, aniline point, saponification number, iodine value, and artificial aging. Several short chapters that follow deal with different lubricants, synthetic oils, fatty oils and fatty acids, graphite, E. P. lubricants, coolants, cutting oils and greases. Another chapter deals with bearing lubrication, including journal and thrust bearings, and ball and roller bearings. The final chapters deal with appliances for lubrication, the lubrication of gears, and cylinder lubrication. The chapter on cylinder lubrication covers internal combustion engines, pumps, compressors, and steam engines.

Factors Affecting Boiling in a Liquid. R. F. LARSON. *Ind. & Eng. Chem.* 37 (1945) pp. 1004-09.

The phenomena of liquid superheat and of nucleate and film boiling in connection with heat transfer were reviewed and studied. On the basis of wettability or interfacial free adhesion energy, a theory for the solid ebullator is evolved. An apparatus to test the theory is described. Various solids were tested to determine their properties as ebullators. Glass, silica, and even stainless steel are not good ebullators. In general, those substances that are chemically inert and resistant to corrosion, support greater superheat of the liquid and are not good ebullators. A bibliography of 64 references is included.

Single-Cylinder Engine Tests of Substitute Motor Fuels. D. B. BROOKS. *J. Res. Natl. Bur. Standards* **35** (1945) pp. 1-37.

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gine, many data were obtained on power output, thermal efficiency and cylinder-head temperature as functions of mixture ratio and spark advance for several fuels, including: reference gasoline (CFR octane No. 72); 190-proof ethyl alcohol; 200-proof ethyl alcohol; 75% ethyl alcohol; 25% ethyl ether; 50% acetone, 50% butyl alcohol, 27% acetone, 6% ethanol, 67% butanol; and 28.5% acetone, 71.5% butanol. In each instance the fuel was studied at compression ratios that gave incipient knock, and also at a standard compression ratio of 5.11, at which the reference gasoline knocked incipiently. At constant compression ratio, 2-5% more power was obtained from the non-hydrocarbon fuels than from gasoline. At the point of incipient knock, the higher compression ratios, ranging up to 9.91 for ethanol, allowed higher thermal efficiencies. Power was as much as 25% greater from ethanol than from gasoline. The rates of burning at the optimum spark advance were substantially the same for all fuels except the ether blend which burned slightly faster. Cylinder-head temperatures for any rate of fuel heat input at incipient knock were almost the same for all fuels.

Determination of Petroleum Oil Spray Deposits on Citrus Leaves. J. B. REDD. *Ind. & Eng. Chem., Anal. Ed.* **17** (1945) pp. 621-23.

In studying the insecticidal efficiency and phytocidal value of petroleum oil spray deposits on citrus, it has been necessary to determine accurately the amount of oil deposited by oil sprays and the amount retained by the foliage over a period of several weeks. To avoid the error introduced through the extraction of variable amounts of plant waxes and at the same time retain the advantages of gravimetric measurement, the author proposes to sulfonate the extract in petroleum ether, separate the petroleum ether containing the unreacted oil, and weigh the residue after evaporating the ether. The method enables the rate of evaporation of petroleum oil from citrus leaves to be followed fairly accurately even when the plant extract is several times greater than the oil remaining on the foliage.

A Nomograph for Emergent Stem Correction of Thermometers. W. T. SOMERVILLE. *Ind. & Eng. Chem., Anal. Ed.* **17** (1945) p. 675.

It is frequently necessary to apply correction factors to thermometers calibrated for total immersion but used at partial immersion. A nomograph is presented that permits the immediate reading of the required correction. Construction of the nomograph is explained, and the data and equation used in its preparation are given.

The Engine Testing of H. D. Oils. Heavy Duty Engine Oil Panel of Standardization Sub-Committee 5—Engine Tests. *Jour. Inst. Petr.* **31** (1945) pp. 362-68.

The Standardization Committee of the Institute of Petroleum decided in 1944 to consider the adoption of engine tests for lubricants, and the Heavy Duty Engine Oil Panel was established in April. Engines have been obtained from Caterpillar Tractor and from General Motors. The work in process is briefly

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described, as well as the special requirements of testing engines. Road testing of lubricants is discussed. The article concludes with the suggestion that the technique of engine testing of lubricants is still in a tentative form. The ultimate aim of the Panel is to provide data from laboratory engine tests to enable a forecast to be made of probable oil behavior in any engine in respect to each important factor affected by the lubricant.

An Automatic Differential Manometer. D. J. LeRoy. *Ind. & Eng. Chem., Anal. Ed.,* 17 (1945) pp. 652-53.

A gage for measuring pressure changes with an accuracy of 0.01 mm. when the total pressure is 50 mm. or more is described. The sensitivity of the instrument is independent of the total pressure and mercury is used as the refining liquid. Pressure changes are read directly from a scale graduated in millimeters.

Kemler Heads Engineering Research at Birmingham

Dr. E. N. Kemler has been appointed head of the newly created engineering research division of Southern Research Institute, Birmingham, Alabama. He comes to the institute from Purdue University where he was professor of mechanical engineering.

In announcing plans for the new engineering research division, it was said the institute will ultimately have a specially equipped laboratory for investigations in mechanical and electrical engineering, and will have a staff competent to handle any problems in design and engineering analysis which may arise in connection with providing a well integrated program of sponsored research. The engineering research division will occupy quarters separate from the main laboratory of the institute, which is now largely occupied with investigations in the physical sciences.

Dr. Kemler has been associated with several companies in a consulting capacity and previously was employed by Dodge Manufacturing Company, University of Pittsburgh, Gulf Research and

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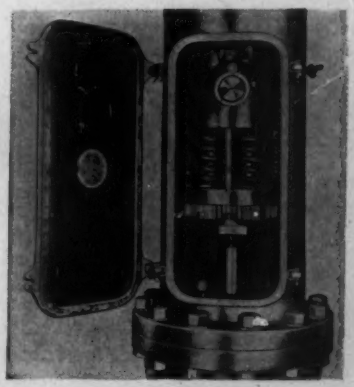

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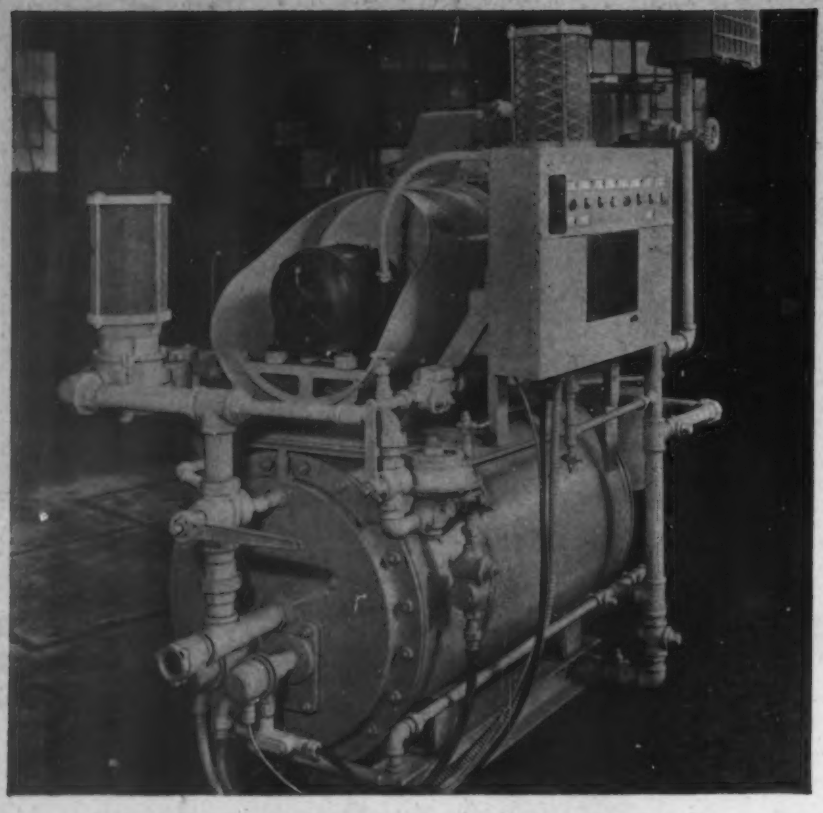

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Development Corporation, and was in charge of production engineering work for the Gypsy Division of Gulf Oil Company at Tulsa. During the war years he was engaged in teaching and research work for the armed forces at Purdue University.

Dr. Kemler is a member of the American Society of Mechanical Engineers, Society for Automotive Engineers, Society for Experimental Stress Analysis, Society for Promotion of Engineering Education, American Petroleum Institute, and Birmingham Engineers Club.

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Cabot Carbon Company has increased capacity of its channel-type carbon black plant in the Estes-North Ward field, Ward County, Texas, from 30 to 38 million cubic feet daily. This plant has been in operation since May, 1937, and obtains a portion of its gas from Gulf Refining Company's gasoline plant in the same area.

Thomas Heads Great Lakes Carbon Research Staff

Great Lakes Carbon Corporation announces appointment of Dr. Charles L. Thomas as director of research, and Dr. L. C. Swallen as assistant director of research.

Dr. Thomas recently joined the research staff of great Lakes Carbon Corporation after 14 years in the Research and Development Laboratories of Universal Oil Products Company. He is a graduate of the University of North Carolina and he received his doctor's degree at Northwestern University. In his professional activities he is vice chairman of the Petroleum Division of the American Chemical Society, and a vice chairman of the Chicago section.

Dr. Swallen came to Great Lakes Carbon Corporation three years ago. Previously he was with the Corn Products Refining Company. He received his doctor's degree at Ohio State University.

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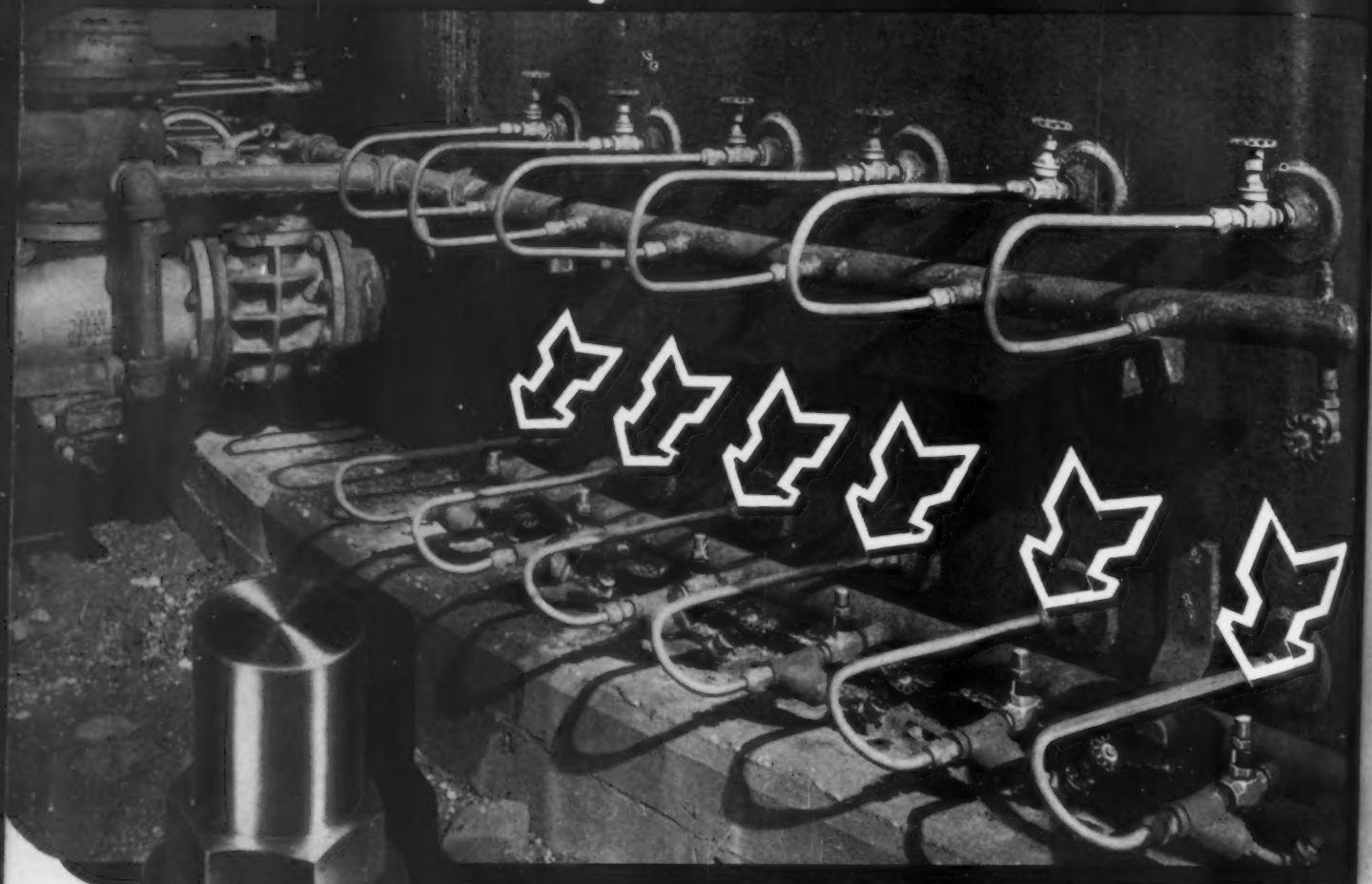

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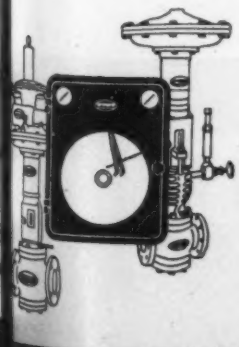

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In Fig. 1, the pilot trap body is full of water, in which the inverted bucket floats and holds the pilot valve closed. Steam and water reach the bucket through the pilot tube that extends from the top of the receiving chamber down to the pilot trap body and up under the inverted bucket.

When water fills the receiving chamber as illustrated in Fig. 2, condensate enters the pilot tube. The inverted bucket then becomes filled with water and sinks, opening the pilot valve. The pilot valve, discharges against the head of the piston, which has an area greater than that of the main valve. This forces the piston up, opening the main discharge valve, and letting water escape from the receiving chamber.

As the main valve opens wide, a relief port is uncovered, reducing the pressure under the piston and preventing excess piston travel. While the bottom of the piston is uncovering the pressure relief port, the skirt of the piston begins to close the main discharge port, which further insures against excessive upward movement of the piston and main valve.

When steam again enters the receiving chamber and flows down through the pilot tube, the inverted bucket floats, closing the pilot valve before all the water leaves the receiving chamber. With the pilot valve closed, pressure is relieved under the piston and it drops, closing the main valve.

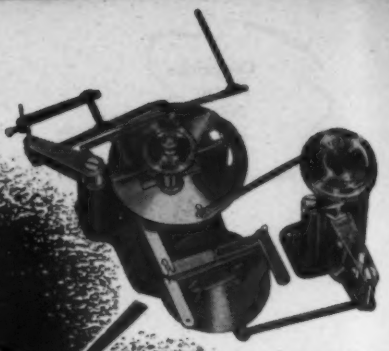
For complete data on this and other Armstrong Traps, write for 36 page STEAM TRAP BOOK.

Fig. 2

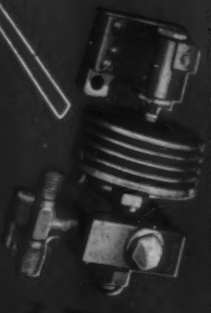
ARMSTRONG MACHINE WORKS

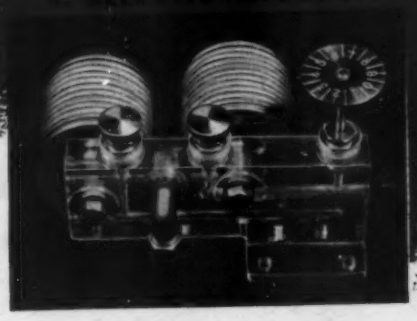
852 Maple Street, Three Rivers, Michigan

1. CONTROL HEAD



2. LINKAGE SYSTEM





New Simplicity in—

RESET CONTROL

This new Metric Reset Controller has only five major sub-assemblies . . . each of which is interchangeable with other reset control instruments of our manufacture.

Throttling range adjustment to the special requirements of a particular process is made by simply turning a knob. (The instrument is adjustable from less than 1% to over 200%.)

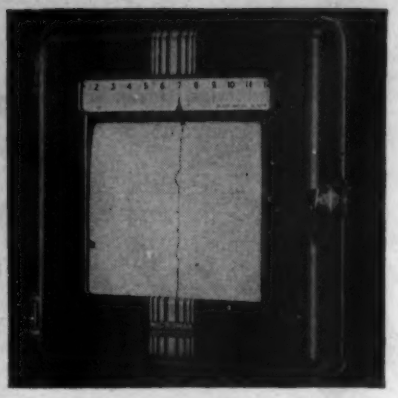
The many advanced features of design and operation of this instrument are described and illustrated in detail in Bulletin E-24. We invite you to write for

AMERICAN METER COMPANY
INCORPORATED (ESTABLISHED 1836)

Albany • Baltimore • Birmingham • Boston • Chicago
Dallas • Erie • Houston • Kansas City • Los Angeles • New York • Philadelphia • Pittsburgh • San Francisco • Tulsa

2309

Atlantic Refining Co.'s Foster-Wheeler alkylation process for high-octane gasoline is controlled from this panel. It employs Micromax Controllers with thermocouples for the debutanizing and depropanizing units, and Micromax Controllers with Thermohms for deisobutanizing.



pH of water from a dehydrator is recorded by this Micromax instrument, to help the operators in a southwestern-USA refinery.

Sulfuric acid concentration is shown by this Micromax Recorder in Atlantic Refining Co.'s Philadelphia plant, as a guide in acid manufacture.

What *Other* Records Can Micromax Give You?

Engineers in most refineries know that Micromax instruments can do an outstanding job of controlling and recording temperature . . . Many engineers also know that Micromax can record one or two other conditions . . . But few engineers have as yet discovered the great variety of Micromax usefulness!

For new light is shed on the operation of almost any process, as soon as Micromax begins to record. The sensitivity; the speed; the accuracy and the readability of the instrument tell operators things they never knew before. Operators usually find it comparatively easy to improve the yield of an acid plant, or the revivification of a catalyst, or the dehydration of a fraction. In other words, the same sort of advantages which Micromax Pyrometers bring to the recording and control of fractionation temperatures are now available for many other conditions.

If you have a problem in which Micromax could apply, an L&N engineer will call or send a catalog, as you prefer.

Acid Strength?
•
CO_2?
•
SO_2?
•
pH?
•
Flow?
•
Level?
•
Pressure?
•
High Temperature?
•
Medium Temperature?
•
Low Temperature?
•
Effluent Neutrality?
•
High-Speed Analyses?
•
Or any one of several others?

LEEDS & NORTHRUP COMPANY, 4923 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

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OUT... IN 14 MINUTES BY "SUB-SURFACE" METHOD

U. S. Navy test on 93′ diameter blazing tank shows . . . "SUB-SURFACE" Method of foam applications kills gasoline fires—when properly engineered foam liquid is used.

MEARLFOAM-5 was successfully employed at this U. S. Navy test at Findlay, Ohio in July 1945. The multi-protein, blended foam-producing liquid is the same dependable mechanical (air) foam liquid supplied to the Navy for shipboard and shore base fire-fighting during wartime—and now supplied to the Navy for peacetime protection.

Ask for condensed data sheet describing the properties of this war-born fire-fighter that yields the live, lasting, fire-resistant (air) foam. *Technical assistance available.*

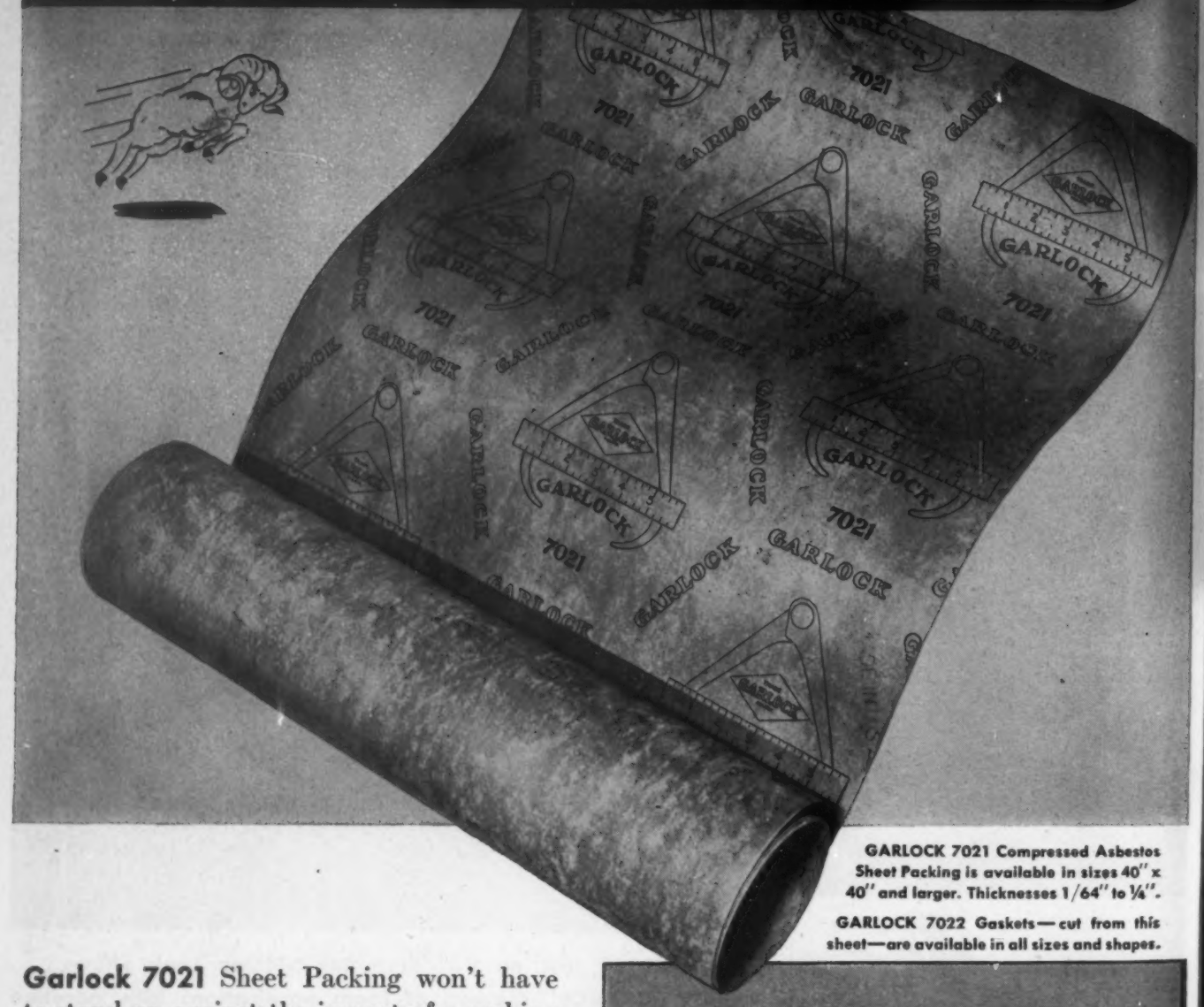
Completely safe and non-corrosive—may be used with standard Mechanical Foam-Forming Equipment

★ ★ MEARLFOAM-5, in pre-mixed solutions with hard or sea water, will not form any objectionable precipitate on long standing.

FOAM ON FIRE OUT... Stays OUT!

THE MEARL CORPORATION
153 Waverly Place, New York 14, N.Y.

"Built to take it!"



GARLOCK 7021 Compressed Asbestos Sheet Packing is available in sizes 40" x 40" and larger. Thicknesses 1/64" to ¼".

GARLOCK 7022 Gaskets—cut from this sheet—are available in all sizes and shapes.

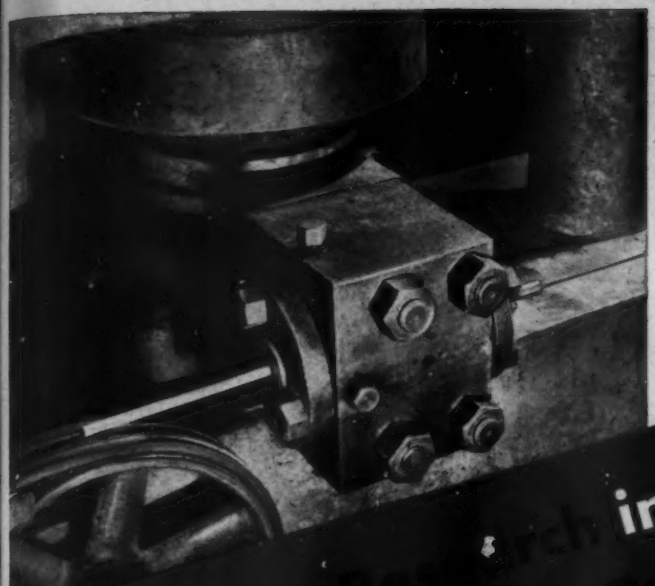
Garlock 7021 Sheet Packing won't have to stand up against the impact of a rushing ram, of course, but if it did we think it could take it. For this compressed asbestos sheet is plenty tough. GARLOCK 7021 gives exceptional service on pipe lines and other equipment handling gasoline, oil, gas or steam at high temperatures and extreme pressures. Avoid gasket failures and expensive shutdowns by standardizing on GARLOCK 7021.

GARLOCK

7021

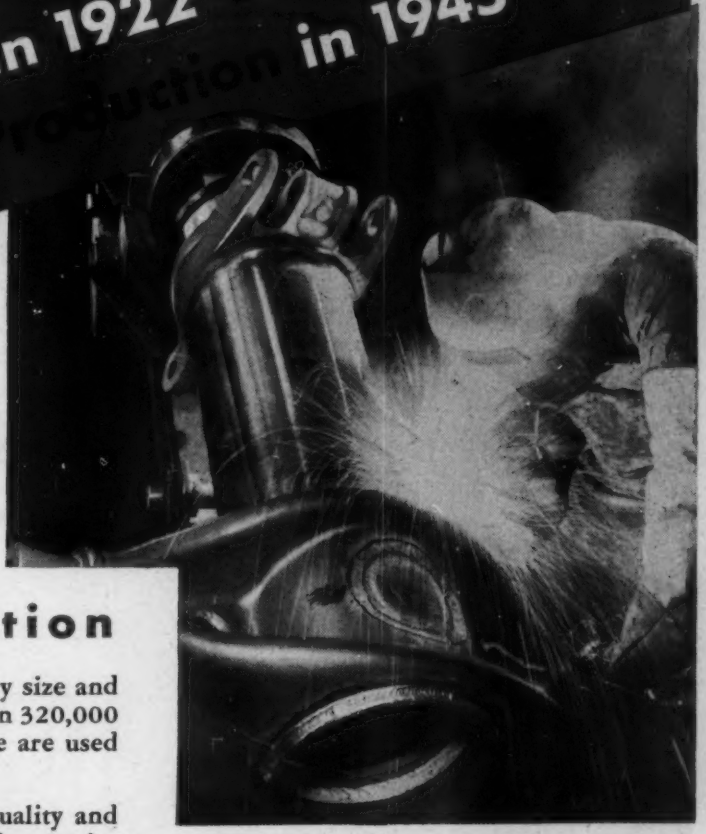
COMPRESSED ASBESTOS SHEET PACKING

THE GARLOCK PACKING CO.
PALMYRA, NEW YORK
Tulsa, Okla. Houston, Tex.
Los Angeles, Calif.



23 YEARS AGO A. O. Smith's unending research to improve weld quality, uniformity, and tensile strength produced the now standard process of applying heavy coatings to electrode wire by extrusion. Weld porosity was virtually eliminated, and SMITHway welds developed tensile strengths substantially greater than the parent metal.

Electrode Research in 1922 Leads to Vital Aircraft-Part Production in 1945



THIS YEAR the continuous march of SMITHway welding research—toward a combination of high strength, high ductility, and utmost dependability—makes possible the mass production of welded landing gears for heavy aircraft such as the B-17, B-24, C-47, and B-29, using types of steels not previously welded in production.

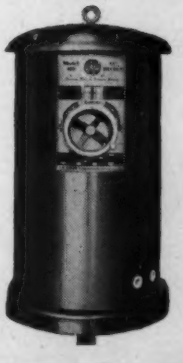
The Proof Is in Production

In its own plants, on parts and products of every size and shape, large and small, A. O. Smith uses more than 320,000 SMITHway Electrodes every day. Millions more are used in the plants of other manufacturers.

And while constant *production* proves their quality and uniformity, constant *research* in A. O. Smith laboratories seeks to improve still further the electrodes that are made *by* welders *for* welders.

For detailed specifications on SMITHway Certified Electrodes and their application to specific welding jobs, send for the SMITHway Welding Catalog.

Mild Steel...High Tensile...Stainless Steel
WELDING ELECTRODES
made by welders...for welders



3 New Models SMITHway A. C. Welders

Expanded to include three new models, the SMITHway line of A. C. Welders—ready for delivery soon—now includes models for 150-, 200-, and 250-ampere capacity, in addition to the 300-, 400-, and 500-ampere Heavy-Duty Models. Write for specifications and prices.

SMITHway Certified WELDING ELECTRODES

A. O. SMITH Corporation

NEW CONSTRUCTION . . . alteration . . . dismantling . . . re-erection . . . of anything from a stack to a complete refinery . . . those are the jobs that Graver Construction Division is doing today to speed the gigantic reconversion program . . . to keep men at work.

The broad experience, trained personnel, and modern equipment of this organization are available to you . . . now. Let us quote on your next job.

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GRAVER TANK & MFG. CO., INC.

General Offices:
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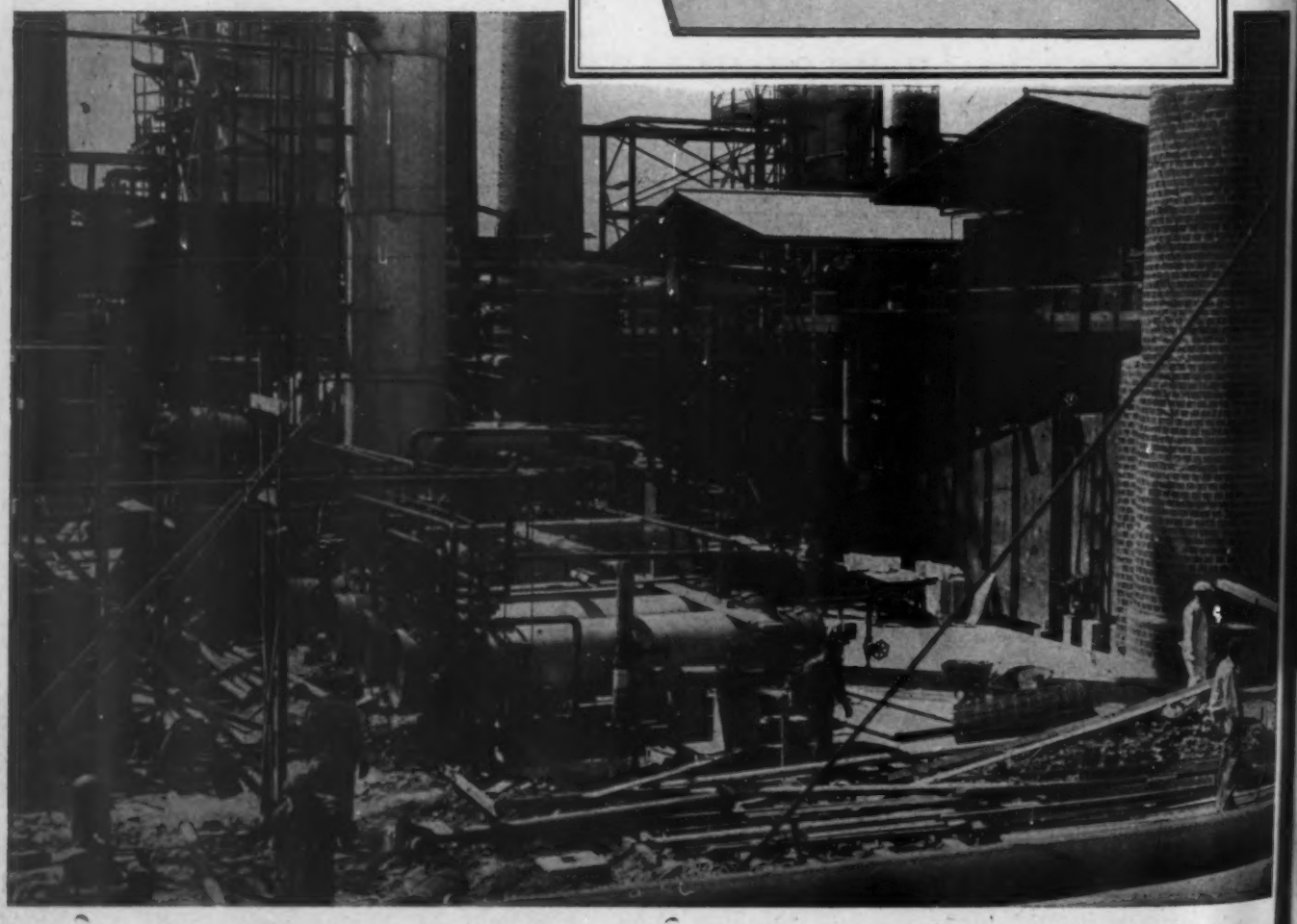
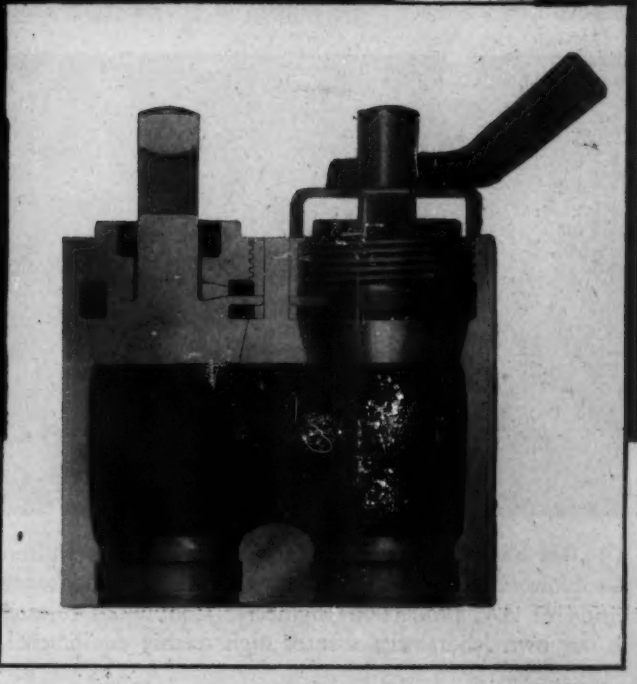
GRAVER
CONSTRUCTION
DIVISION



From the inside out . . .

IT'S NEW IT'S QUALITY IT'S OHIO

The OHIO Type 1640



The new Ohio Type 1640 Return Bend has the strongest top construction in use today! With this feature the 1640 has already earned a higher pressure-temperature rating than any other type of fitting. Write for details about this and the many other advantages of the new Ohio Type 1640.

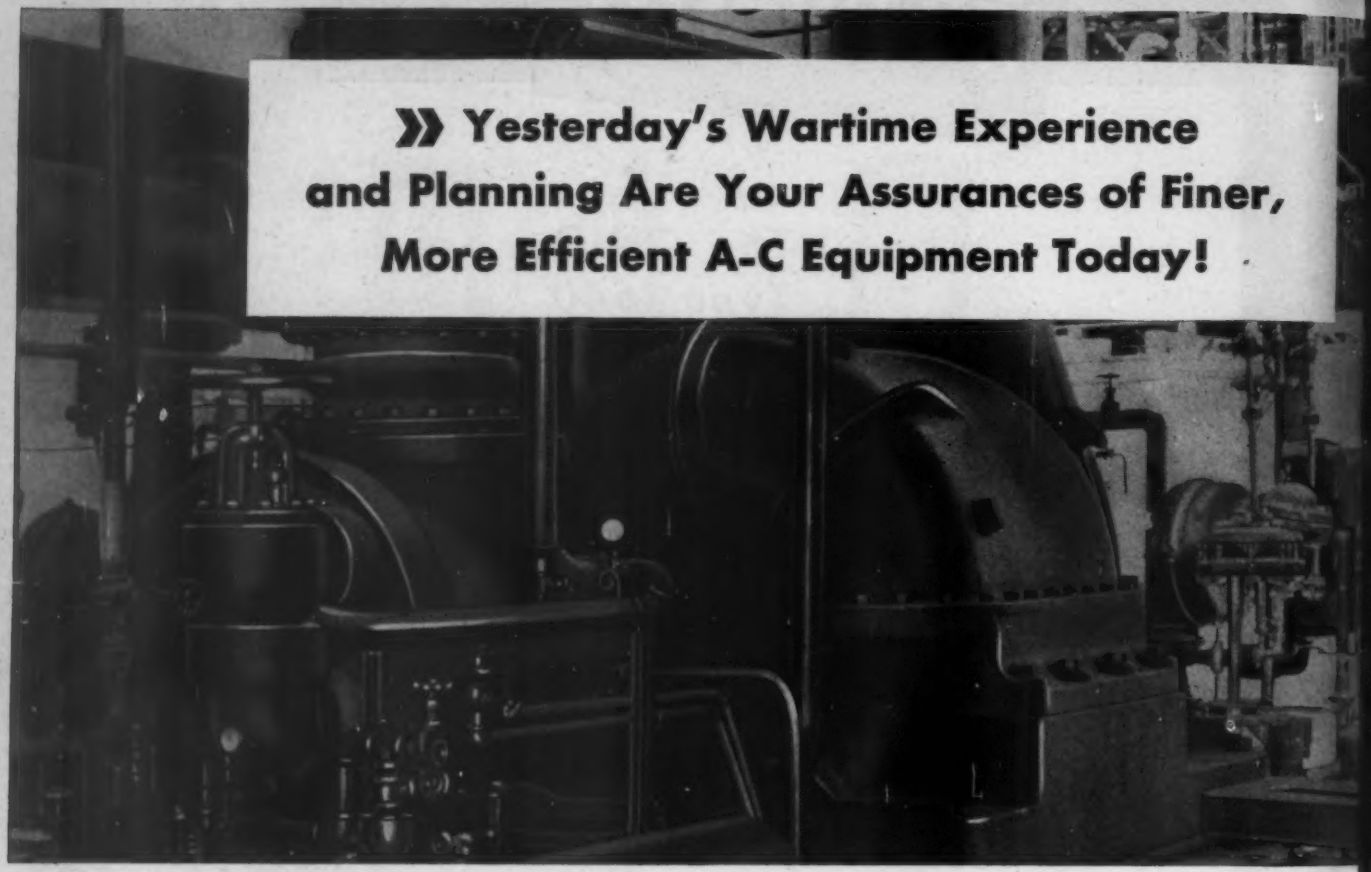
The OHIO STEEL FOUNDRY CO.

SPRINGFIELD, OHIO • Plants in Lima and Springfield, Ohio

ENGINEERS • FOUNDERS • MACHINISTS

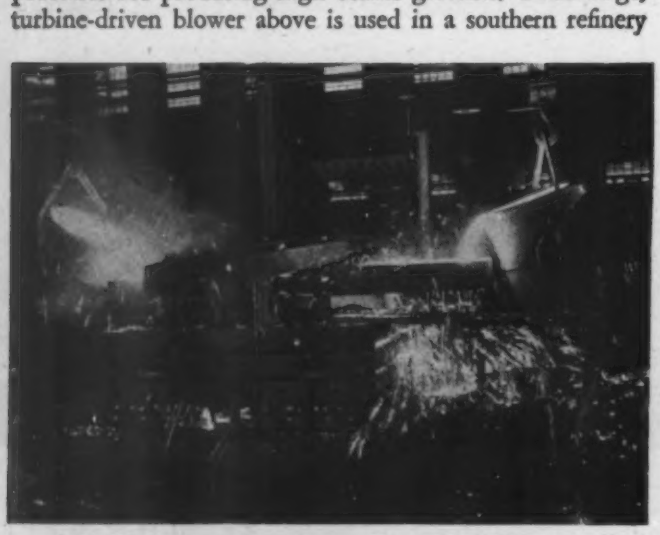
FREE ENTERPRISE IS THE ONLY WAY TO CONSTANTLY HIGHER AMERICAN LIVING STANDARDS

Allis-Chalmers Reports t

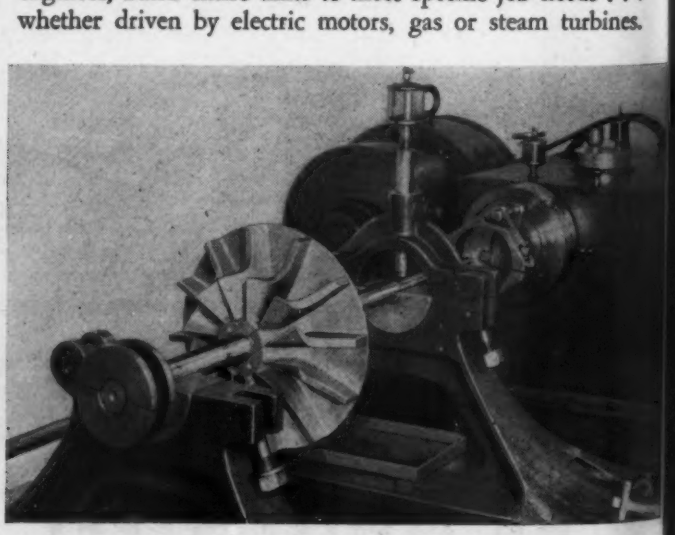


» Yesterday's Wartime Experience and Planning Are Your Assurances of Finer, More Efficient A-C Equipment Today!

1 **Allis-Chalmers** is the only U. S. manufacturer to apply both gas and steam turbine driven units to job of furnishing large volumes of air under pressure in catalytic processes for producing high octane gasoline. Multi-stage, turbine-driven blower above is used in a southern refinery to force needed air through various stages of the fluid catalyst process. A-C is a major supplier of blowers to the *entire* petroleum industry. It is best equipped to design, engineer, build entire units to meet specific job needs . . . whether driven by electric motors, gas or steam turbines.

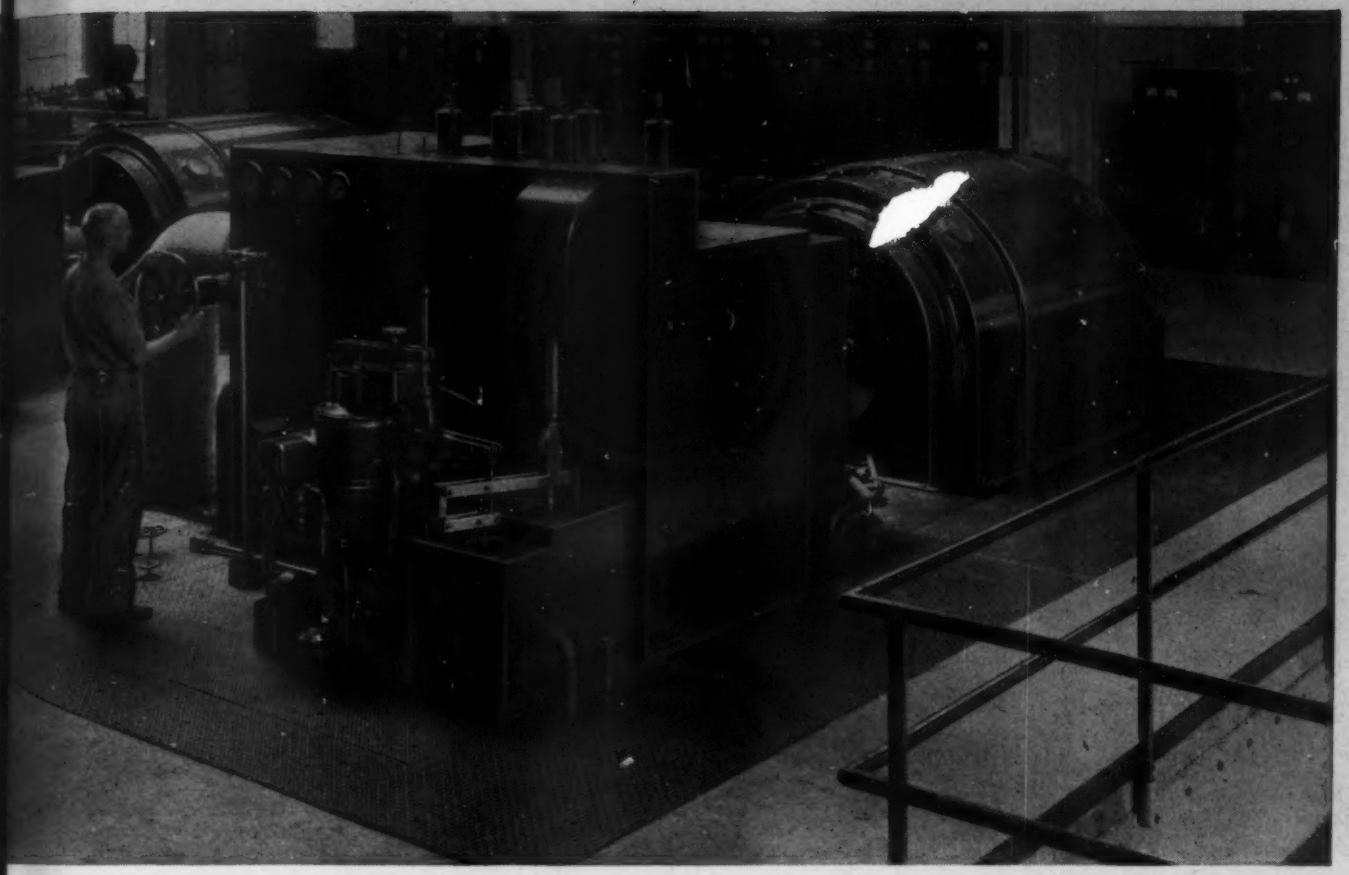


2 **All Forgings** and castings for Allis-Chalmers turbo-blowers are made in A-C's own shops . . . under supervision of A-C production engineers. Continuous research in our own laboratories assures high quality equipment!



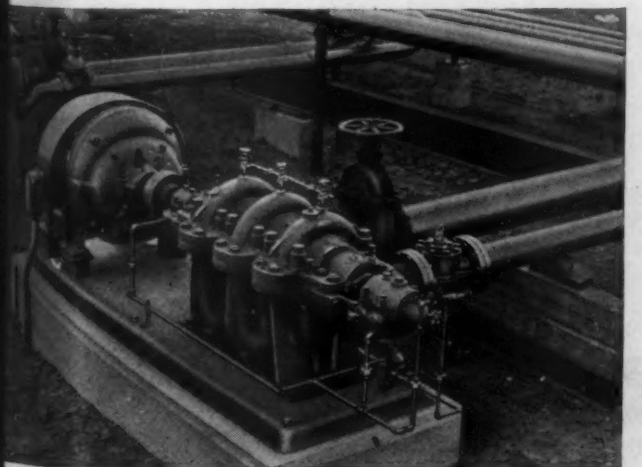
3 **All Impellers** for A-C turbo-blowers are carefully balanced in a special machine to insure smooth running action, freedom from vibration. Severe tests are given all equipment before it is shipped from A-C's plants.

s to U.S. Oil Refiners!



4 For Oil Refineries where process steam is required in addition to power, Allis-Chalmers builds non-condensing steam turbines to supply power and steam . . . *both under governor control.* In some cases, such as that of the 3500 kw machines shown above, the new turbine operates at economical high pressure . . . exhausting to older low pressure units which in turn supply process steam. In addition, A-C engineering provides other equipment oil-men have learned to rely on: electric motors and controls, Texrope V-belts, "Magic-Grip" Sheaves.

A 1974



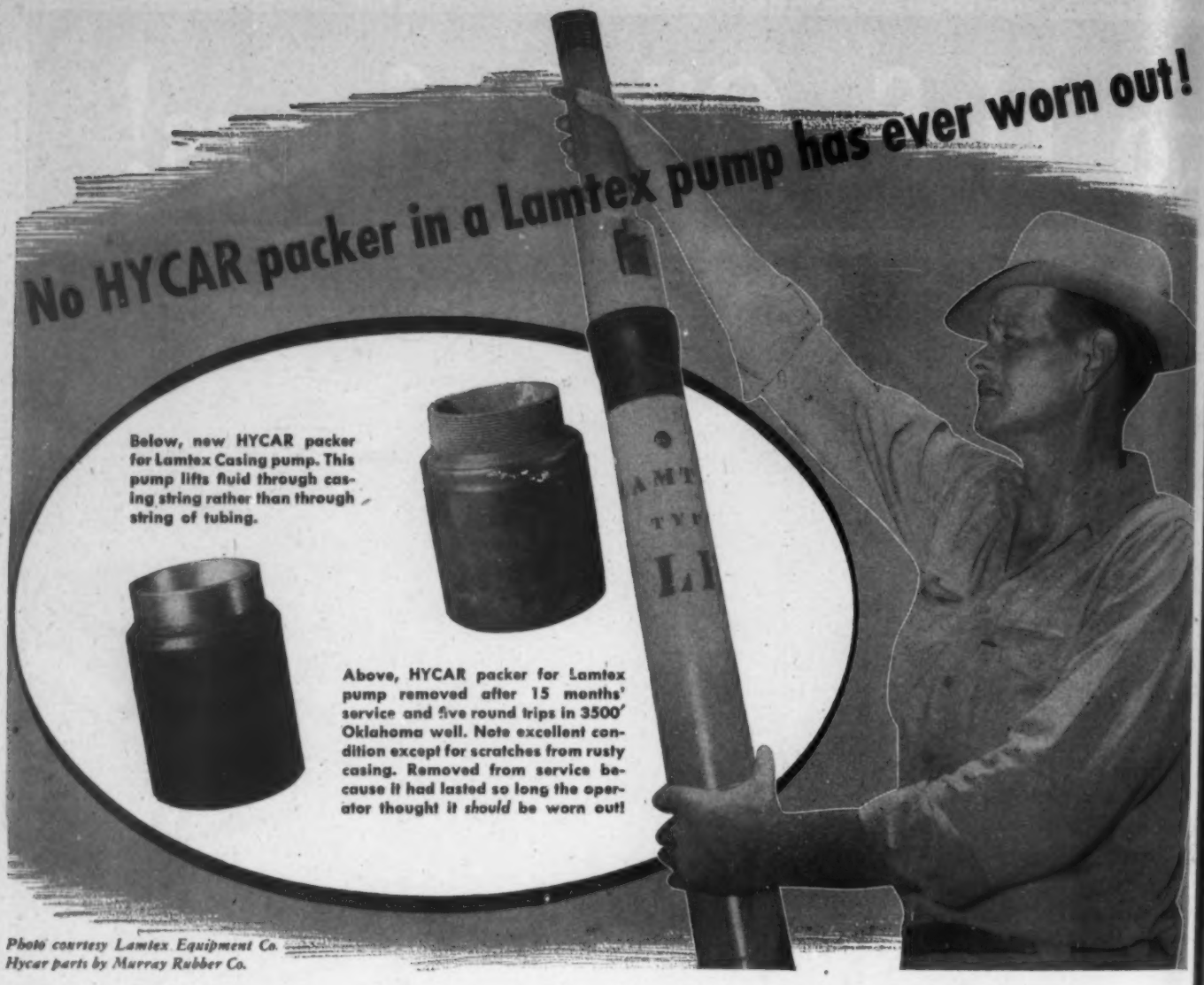
5 All Types of pumps are designed and built by A-C for all stages of petroleum operations . . . production, refinery, pipeline or terminal. Call your nearby A-C office, or write ALLIS-CHALMERS, MILWAUKEE 1, WIS.

ALLIS-CHALMERS

PRODUCER OF WORLD'S LARGEST LINE OF MAJOR INDUSTRIAL EQUIPMENT

HEAR THE BOSTON SYMPHONY: *Saturday, American Broadcasting Co.*

No HYCAR packer in a Lamtex pump has ever worn out!



Below, new HYCAR packer for Lamtex Casing pump. This pump lifts fluid through casing string rather than through string of tubing.

Above, HYCAR packer for Lamtex pump removed after 15 months' service and five round trips in 3500' Oklahoma well. Note excellent condition except for scratches from rusty casing. Removed from service because it had lasted so long the operator thought it *should* be worn out!

Photo courtesy Lamtex Equipment Co.
Hycar parts by Murray Rubber Co.

NO signs of deterioration in oil or gas; no sticking to casing walls; no permanent set—packer springs back into shape when pressure is removed; no evidence of abrasion except when used in rusty, corroded casings; the best material he has ever used!

These are a few of the things said about HYCAR packers used in Lamtex pumps by one Oklahoma operator who knows the answers.

They're typical of remarks made about many different kinds of HYCAR parts in the oil fields—casing head seals, slush pump packers, mud line valves, hose, gaskets and seals, and many others. The properties in the list at the right tell why HYCAR has become practically the standard resilient material for oil field use. Its applications extend to every part of the oil industry—producing, refining, transportation, and marketing.

Ask for parts made from HYCAR for test in your own applications—difficult or routine. You'll learn for yourself that it's wise to use HYCAR for long-time, dependable performance. *Hycar Chemical Company, Akron 8, Ohio.*

WHAT HYCAR DOES IN OIL FIELD APPLICATIONS

1. *Resists oil and gas—even under high pressures and temperatures.*
2. *Resists action of abrasive-laden fluid under high pressure and at high velocity.*
3. *Wears at slow rate even under worst conditions.*
4. *Makes a positive, leak-proof seal, even after a long period of service.*
5. *Provides high elasticity.*
6. *Gives high tensile strength.*
7. *Has minimum tendency to cold flow and compression set.*

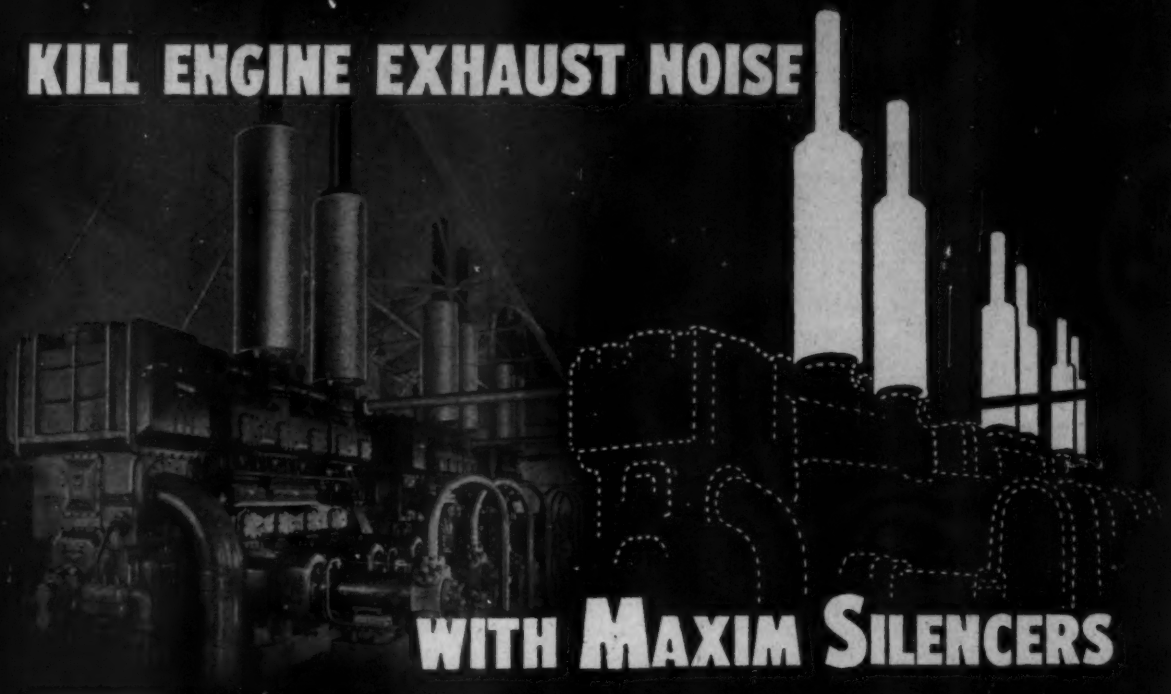
Hycar

Reg. U. S. Pat. Off.

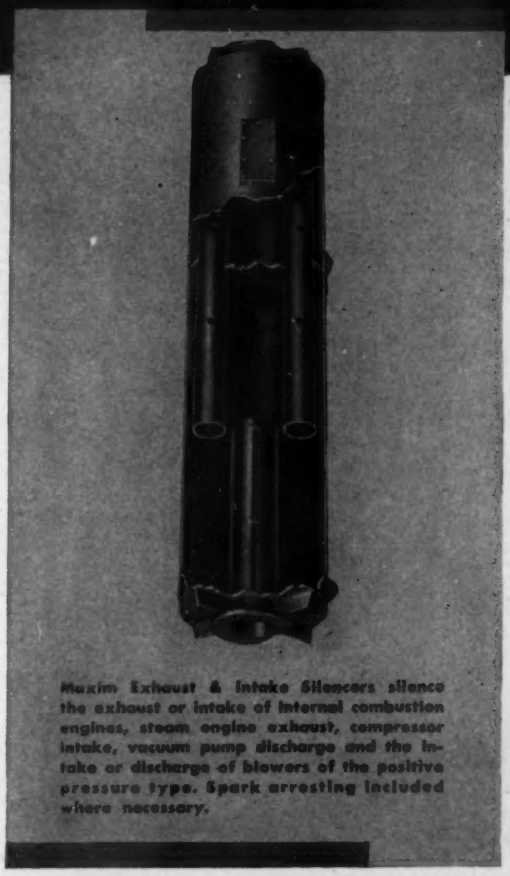
LARGEST PRIVATE PRODUCER OF BUTADIENE TYPE

Synthetic Rubbers

KILL ENGINE EXHAUST NOISE



WITH MAXIM SILENCERS



Maxim Exhaust & Intake Silencers silence the exhaust or intake of internal combustion engines, steam engine exhaust, compressor intake, vacuum pump discharge and the intake or discharge of blowers of the positive pressure type. Spark arresting included where necessary.

Adequate silencing of engine exhaust noise is an operating necessity today. The engines shown above could, without proper silencing, make a public disturbance that would quickly be felt by those in charge of plant operation. With Maxim Silencers, however, exhaust noise can be reduced to a point where it is scarcely audible.

Maxim engineers will be glad to recommend the correct silencing equipment to best meet your particular problem. Send your specifications to the address given below.

Maxim also makes Heat Recovery Silencers which combine efficient silencing, spark arresting, and the recovery of waste exhaust heat to produce steam or hot water for heating or processing operations. These are described in Heat Recovery Bulletins WH 100, WH 101 and WH 103.

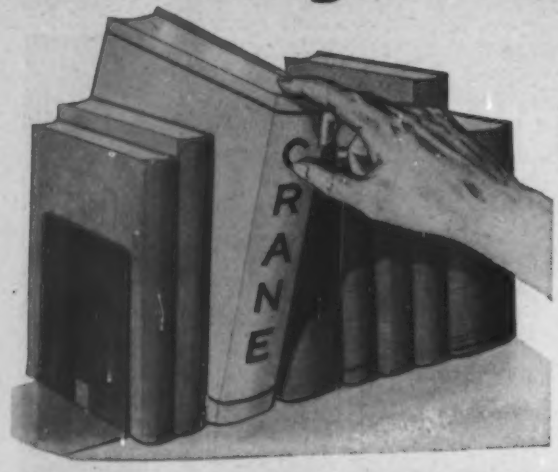
WRITE FOR BULLETINS describing exhaust & intake silencers D 125, D 127, D 101, D 37.

THE MAXIM SILENCER CO. 79 HOMESTEAD AVE., HARTFORD, CONN.

ARMY E NAVY

MAXIM

The Finger Points to CRANE ...when the need is Piping Materials



ONE SOURCE OF SUPPLY . . . ONE RESPONSIBILITY . . . ONE STANDARD OF QUALITY

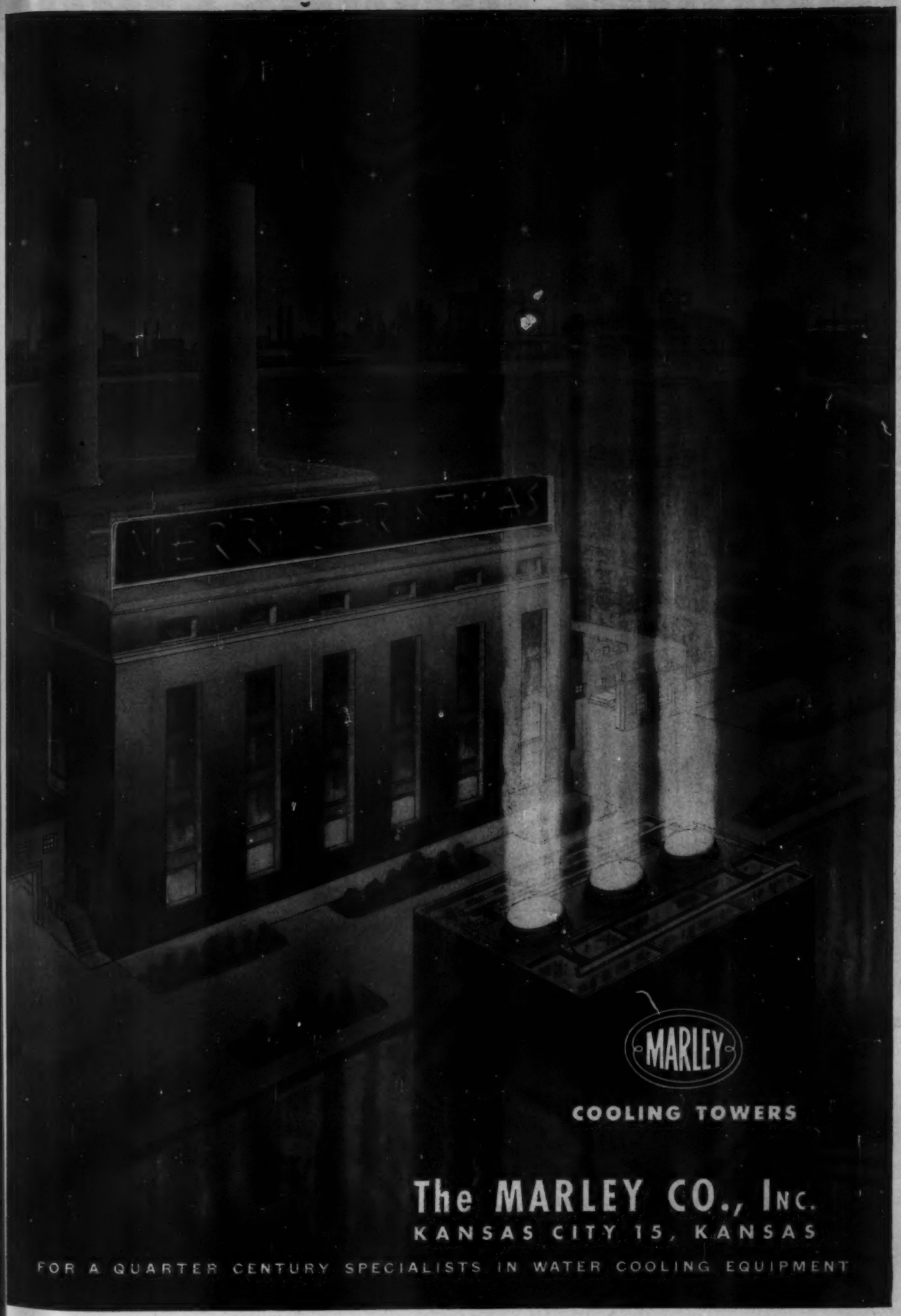
● When you depend on a single source—your Crane Branch or Wholesaler—you are assured of getting piping materials to suit your needs. You choose from the world's greatest line—in brass, iron and steel. You know that all materials are uniform in quality—with one responsibility and 90 years' manufacturing experience behind them. To keep piping at peak efficiency—to simplify and speed up deferred replacement work—keep this *complete* Crane service in mind. For a typical Crane solution to many of your gate valve needs, see below.

Gasoline treating plant

SERVICE RECOMMENDATIONS: Crane Cast Steel Wedge Gate Valves are made in all pressure classes up to 2500 pounds and for temperatures up to 1100° F. The 150-pound class, illustrated in cross-section, with Exelloy to Exelloy trim, is suited for all oil and oil vapor services at temperatures up to 500° F. With "H" trim of Crane Special Brass, these valves are recommended for steam, water, gas, and air services at temperatures not exceeding 500° F. Screwed end valves are available in sizes up to 4 in.; flanged end valves up to 24 in. See your Crane Catalog for complete specifications.

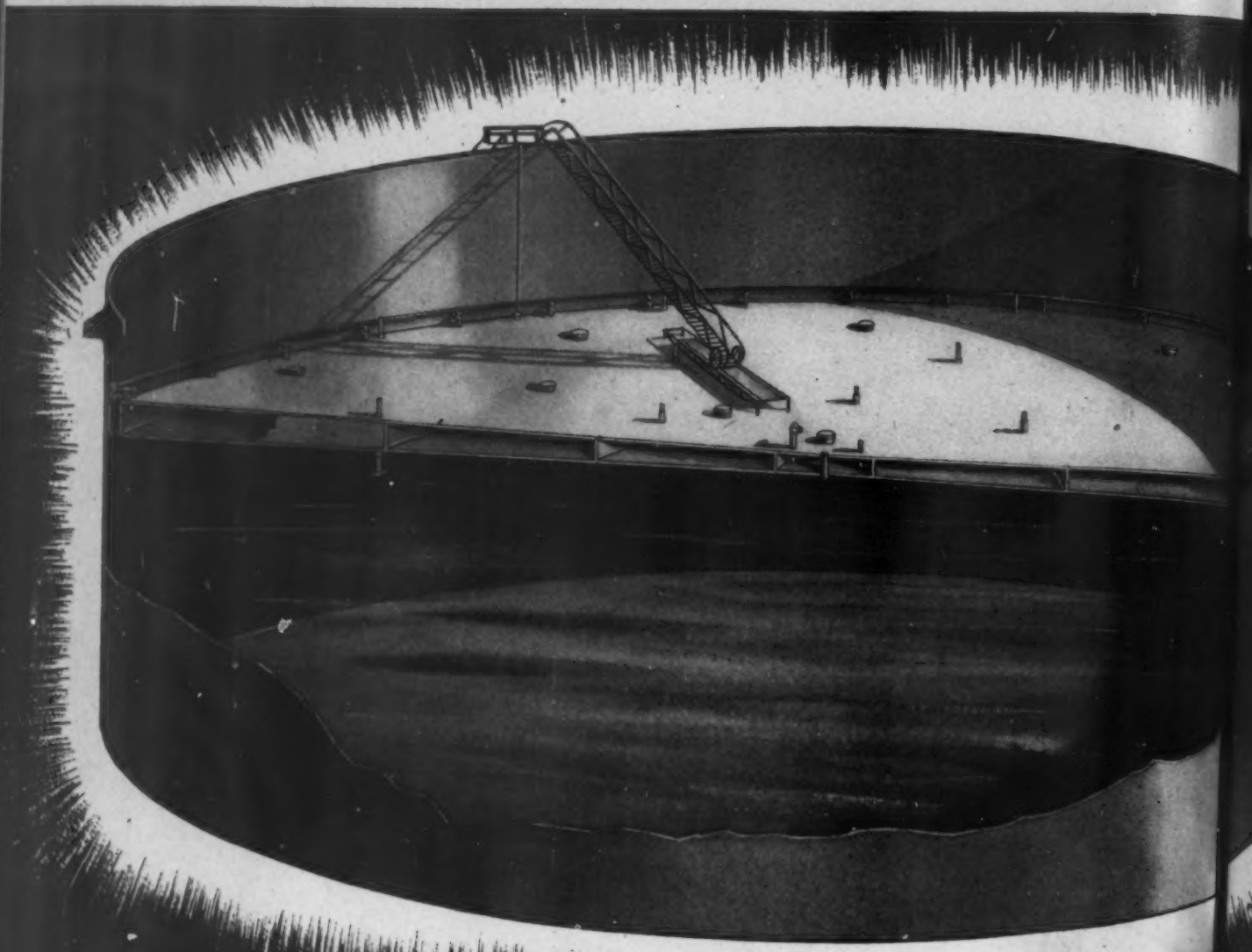
CRANE CO., General Offices: 836 S. Michigan Ave., Chicago 5, Ill. • *Branches and Wholesalers Serving All Industrial Areas*

CRANE VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS


MARLEY
COOLING TOWERS
The MARLEY CO., INC.
KANSAS CITY 15, KANSAS
FOR A QUARTER CENTURY SPECIALISTS IN WATER COOLING EQUIPMENT

CHICAGO BRIDGE & IRON

a complete line of evaporation



the FLOATING ROO

Construction and operating features of the Horton Floating Roof . . . a double-deck roof of improved desi

Double-deck construction insulates liquid and prevents boiling. This extends the range of products that can be stored in tanks with floating roofs.

Entire bottom of deck is in contact with liquid, reducing corrosion.

Practically unsinkable and extremely stable.

Deck drains rapidly to screened opening at center. Water collecting on the roof when drain is closed does not lessen stability.

Open sump draining rain water into tank, pipe drain or flexible hose optional. No siphon necessary with open sump.

Bottom of deck coned up toward center, facilitating the venting of air trapped under deck when the roof is floated or the collecting of entrain vapors which are held until they recondense.

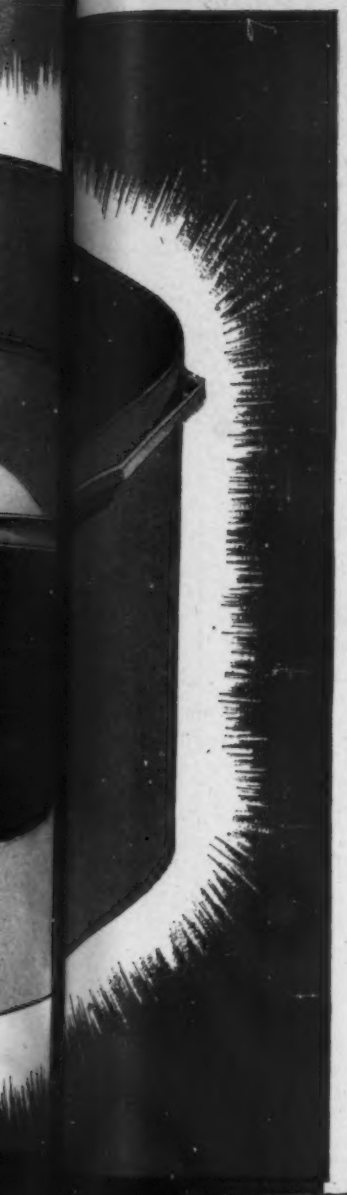
Top of deck smooth and free of obstruction.

Space between deck and tank shell closed effective seal which forms a long sliding cont with tank shell. Secondary seals supplied wh product stored requires added protection.

Installed complete with adjustable suppor gauge hatch, bleeder vent, drain, emergency dra and manholes.

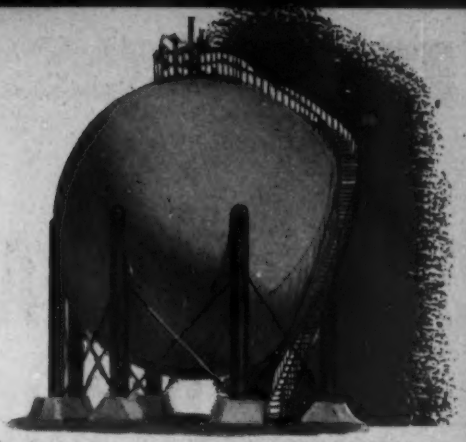
Embodies the engineering experience and s acquired by Chicago Bridge & Iron Company designing, fabricating and erecting floating ro since 1923.

COMPANY builds saving equipment

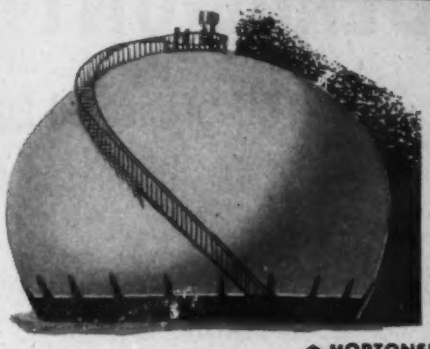


ADVANCED technical processes in refining and blending have created the need for more efficient evaporation saving equipment. Oil companies can materially reduce the evaporation of volatile hydrocarbons during the storage periods between production, refining, blending, and marketing, with the equipment shown here. These products embody the engineering experience and skill acquired during twenty-two years of designing, fabricating, and erecting evaporation saving equipment for the petroleum industry.

We invite you to write our nearest office for further information on these products.

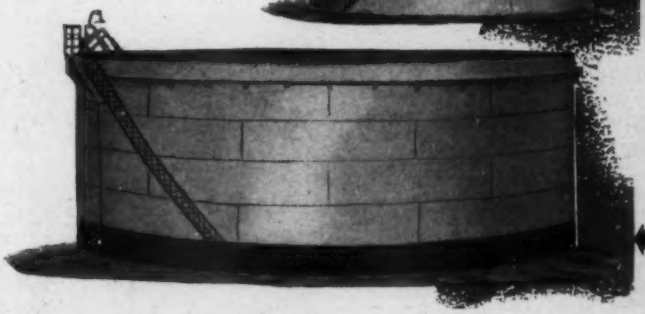


HORTONSPHERES . . . *are used by the petroleum industry for the storage of highly volatile liquids and gases. They prevent evaporation loss by allowing pressure to build up inside the tank instead of venting. Available in standard capacities from 1,000 to 25,000 bbls. for liquids, and from 20 to 65 ft. in diam. for gases.*



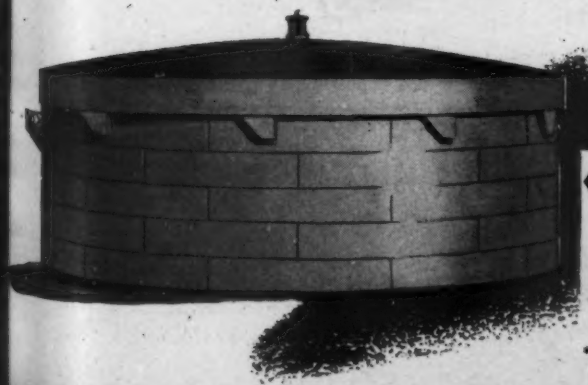
HORTONSPHEROIDS . . . . . . *for storing hydro-carbons ranging in volatility from motor fuel to natural gasoline. Smooth Hortonspheroids are built in capacities of 2,500 to 40,000 bbls. for pressures from 2½ to 35 lbs. per sq. in. and noded designs from 20,000 to 120,000 bbls. for 2½ to 20 lbs. pressure.*

HEMISPHEROIDS . . . . . . *provide an economical means of storing liquids requiring pressures of only 2½ to 10 lbs. per sq. in. to stop standing storage losses under normal operating conditions. Built in sizes from 2,500 to 20,000 bbls. (Noded Hortonspheroids are used for capacities over 20,000 bbls.)*



WIGGINS* FLOATING ROOFS . . *are supplied for installations where the volatility of the oil does not require the insulating qualities of the Horton roof. These roofs, in varying specific forms, have been used extensively on tanks storing sour crude oil and will hereafter be available in forms particularly well adapted for this use.*

WIGGINS BREATHER* ROOFS . . . *are used to reduce breathing losses on standing storage tanks. They are particularly recommended for tanks 60 ft. in diameter or larger that are kept full or nearly full most of the time.*



HORTON LIFTER ROOFS . . . . . . *reduce evaporation losses from standing storage or slow working tanks. The vapor spaces of several adjoining cone roof tanks are often connected to the vapor spaces of a tank with a lifter roof.*

CHICAGO BRIDGE & IRON COMPANY

Atlanta • Birmingham • Chicago • Cleveland
Havana • Houston • Los Angeles • New York
Philadelphia • San Francisco • Tulsa • Washington

** Chicago Bridge & Iron Company Trade Mark*

ALCO ACQUIRES BEAUMONT IRON WORKS

ALCO-Engineered Equipment Now Available for all phases of the Oil Industry

ALCO PRODUCTS' postwar manufacturing and service set-up for the Oil Industry has been advanced with the acquisition of Beaumont Iron Works.

This merger brings to the oil industry the advantages of being able to buy drilling, producing and refining equipment from a single dependable source.

The high standards always associated with ALCO Heat Exchangers, Pressure Vessels and Prefabricated Piping, and with Beaumont Oil-Well-Drilling and Production Equipment, will be firmly maintained by the present Beaumont and Alco management and personnel.

Jones & Laughlin Supply Company will continue as exclusive stock distributor of the Beaumont line.

ALCO is now prepared to supply, design, or build to your specifications, oil-drilling, producing and refining equipment units and components including:

- Drawworks
- Crown Blocks
- Traveling Blocks
- Tubing Blocks
- Diesel Engines
- Pumping Blocks
- Casing Heads
- Well-Head Assemblies
- Alloy Steel Castings
- Heat Exchangers
- Steam-Generating Equipment
- Coring Reels
- Prefabricated Piping
- Pressure Vessels
- Steel-Plate Work
- Weldments
- Air-Cooled Heat Exchangers
- Large-Diameter, Electric-Welded Steel Pipe

American Locomotive Company

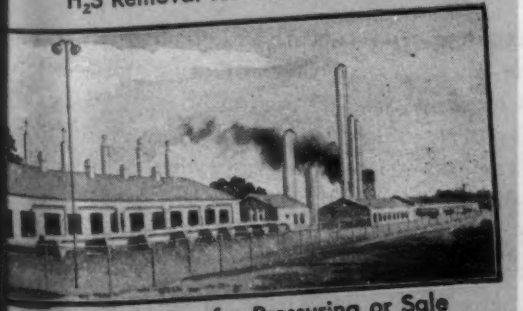
ALCO PRODUCTS DIVISION

Plants: Dunkirk, N. Y. • Beaumont, Texas. Main Office: 30 Church St., N. Y. 8, N. Y.

BEAUMONT IRON WORKS COMPANY

SOUR GAS *made Marketable Profitably*

H_2S Removal for Carbon Black Plants



Treated Gas for Pressuring or Sale

PRITCHARD has executed *turn-key* contracts for natural gas processing facilities of every kind, including many for

DESULPHURIZATION and DEHYDRATION

Years of Pioneering Research and Practical Experience in the
DESIGN . . . ENGINEERING . . . AND CONSTRUCTION OF COMPLETE UNITS

To be sure of on-time completion and *profitable* operation refer your requirements to our staff of veteran engineers.

NATURAL GAS DIVISION

J.F. Pritchard & Co.

ENGINEERS AND CONSTRUCTORS
FOR THE CHEMICAL • PETROLEUM • GAS AND POWER INDUSTRIES
Manufacturers of Mechanical and Atmospheric Cooling Towers

FIDELITY BUILDING, KANSAS CITY 6, MO.

New York · Pittsburgh · Houston · Atlanta · Tulsa · Denver · El Paso · Omaha · Salt Lake

WORLD'S TOPS in topping capacity

Abadan, South Iran, site of this huge Anglo-Iranian Oil Company refinery, is in one of the world's most important producing areas.

In 1936 Badger designed and supplied a crude topping and vacuum unit rated at 71,000 bbls. per day of crude charge. So satisfactory was the performance that three more were purchased in 1937, 1939 and 1945, respectively. Thanks to the close co-operation with the refinery technicians which Badger engineers always strive to achieve, these units have all consistently operated at up to 86,000 bbls. per day crude input with closer cutting than ever. BADGER KEEPS ON TOP.

The aggregate crude run by these four units since commissioning exceeds—

HALF A BILLION BARRELS

Badger designing, constructing and erecting experience covers the entire range of distillation units—from largest to smallest. Badger knows how to modernize or replace older types of units toward obtaining more close-cut fractions—thus broadening the refiner's stocks for profitable specialized purposes.

LICENSING AGENTS FOR THE TCC PROCESS AND THE HOUDRY CATALYTIC CRACKING PROCESSES

Photo courtesy Anglo-Iranian Oil Co.

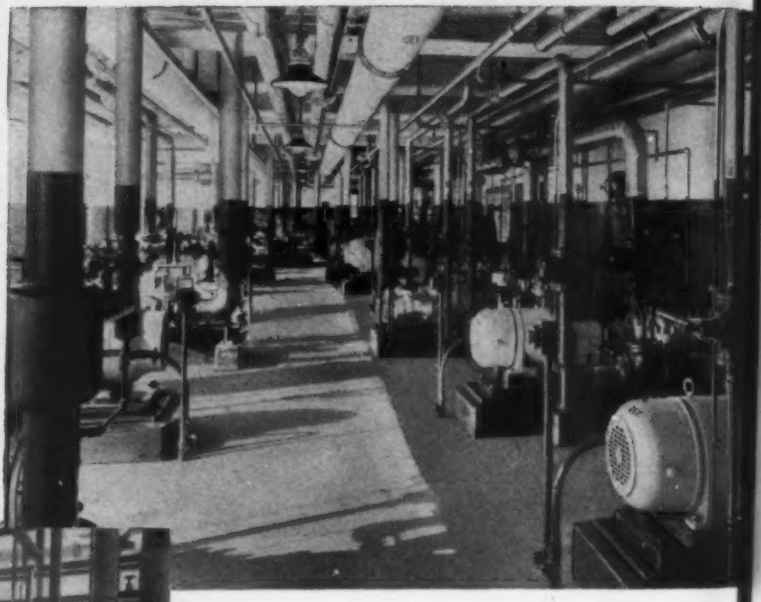
The largest refinery in existence now operates four **Badger**-designed topping and vacuum units

E. B. Badger & SONS CO., Est. 1841

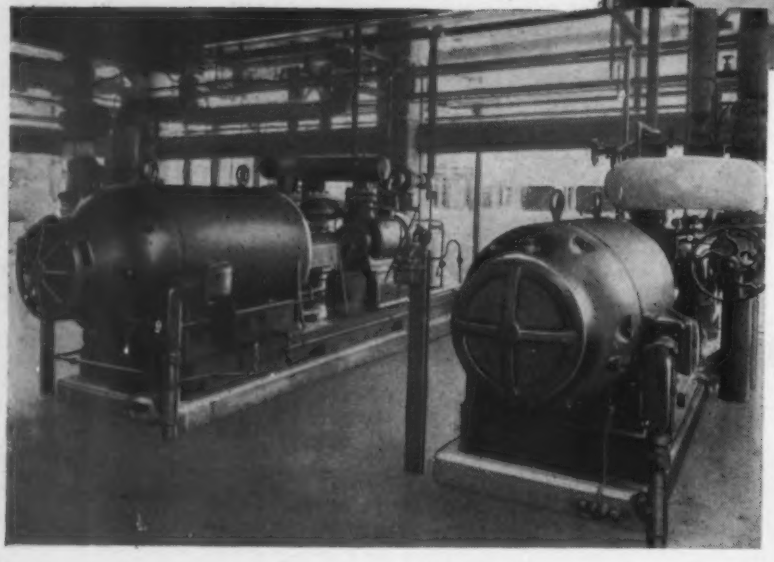
BOSTON 14 • NEW YORK • PHILADELPHIA • SAN FRANCISCO • LONDON

PROCESS ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM, PETRO-CHEMICAL AND CHEMICAL INDUSTRIES

You don't fence 'em in...



Main pump room in a refinery. The pumps are driven by G-E totally enclosed, fan-cooled, squirrel-cage induction motors ranging in size from 25 hp to 250 hp, 3000 rpm.



Tutwiler Refinery of the Cities Service Oil Company at Lake Charles, La.—Two large, totally enclosed, fan-cooled, explosion-proof, squirrel-cage induction motors, each coupled to a centrifugal pump. The motor at the left is a 600-hp, 3600-rpm Type K, and the one at the right is a 500-hp, 3600-rpm Type K-6339Z.

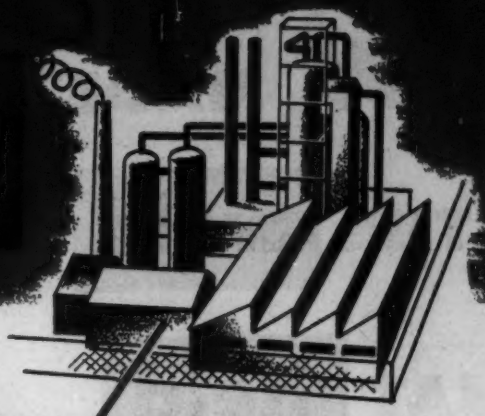
GE

MOTORS AND CONTROL

For Hazardous Areas

Keep on buying BONDS—*and keep all you buy*

You don't fence 'em out!



You put these explosion-proof motors and controls right on the spot in hazardous areas. No costly vaults, no awkward remote drives are needed to meet refinery hazards.

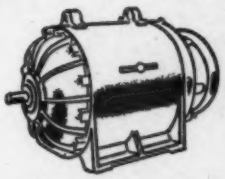
YOU save engineering time and construction costs on your refinery-expansion projects when you make the widest possible use of explosion-proof electric equipment. You'll eliminate the need to plan and build costly "isolation wards." You'll avoid the necessity for clumsy remote-drive arrangements. You'll simplify subsequent plant maintenance.

Use of G-E explosion-proof motors and controls, applied with the aid of experienced G-E application engineers, can also mean lower insurance costs and greater protection against unscheduled shutdowns. For you will have the very best in electrical safety. Whether it's gasoline, naphtha, or natural gas, there is a practical way to solve your problem with a combination of G-E motors and control. General Electric builds America's most complete line of motors and control devices for use in both Class I and Class II locations.

G-E engineers, specializing in refinery applications, will gladly work with you to get the best combination of safety, economy, and operating convenience in your electrical layouts. They can be reached quickly through the G-E office in your area.

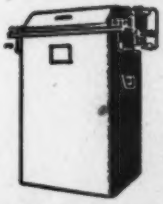
Apparatus Dept., General Electric Company, Schenectady 5, N. Y.

G-E Explosion-proof Equipment for Refineries

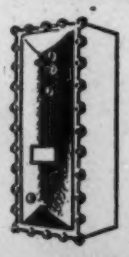


G-E Motors—Available types include squirrel-cage, wound-rotor gear-motors, brake-motors, and motor-generator sets in sizes ranging from fractional-hp to 1000 hp, 3600 rpm.

G-E Vertical Motors—Provide extra security in pumping liquids from underground tanks. Nonsparking ratchet prevents reverse rotation and damage to pump. Most types and ratings available in horizontal explosion-proof motors can be had in vertical motors.



G-E Air-break Starter—This combination starter is available in magnetic or manual types for full- or reduced-voltage starting, from 1 to 100 hp.

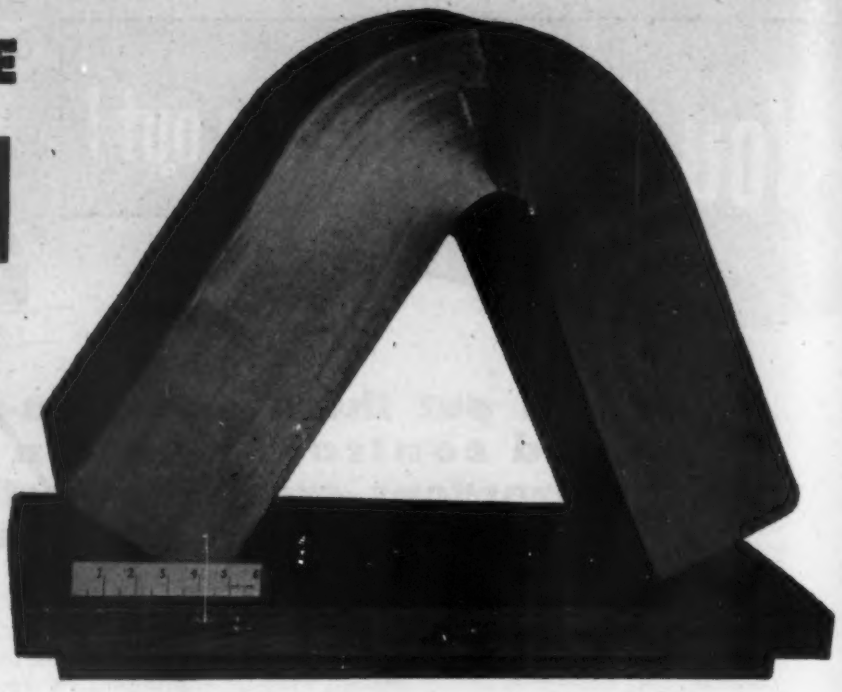


G-E Oil-immersed Starter—This highly protected unit may be had in ratings from 5 to 3500 hp for full- or reduced-voltage starting.

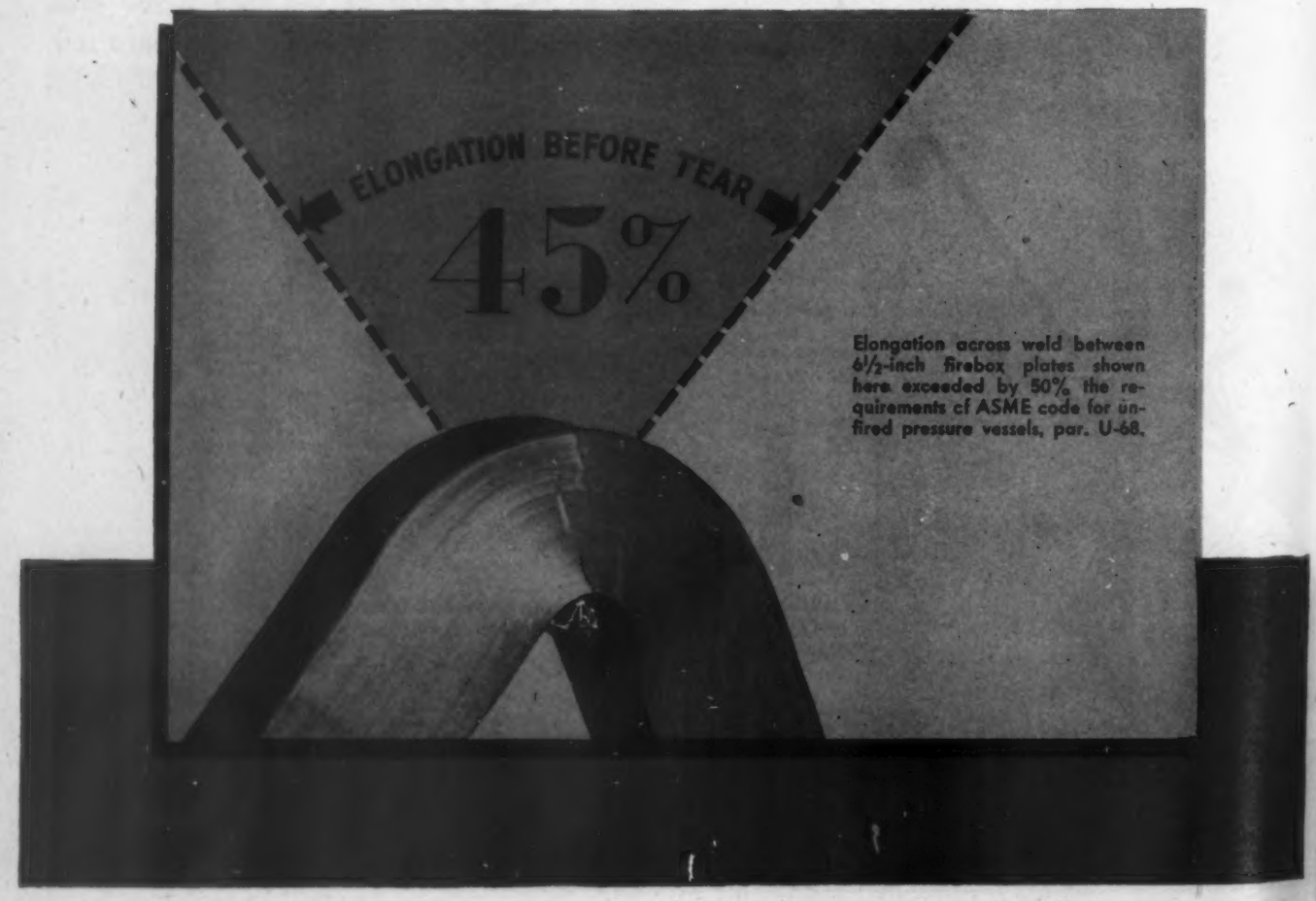
GENERAL ELECTRIC

Sample of butt welded 6½-inch firebox plate A.70 after face bend test.

B&W MADE THE weld THAT held

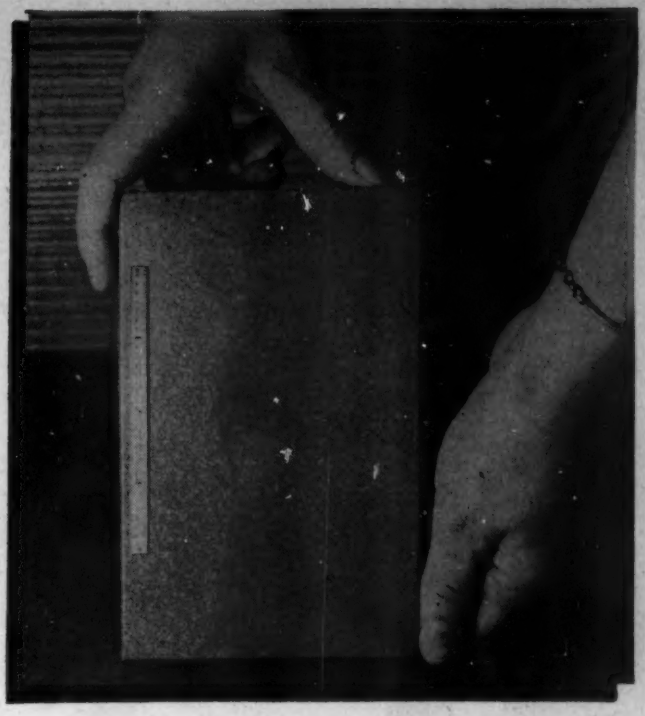


...and 6½ inch firebox plate became a pressure vessel



Elongation across weld between 6½-inch firebox plates shown here exceeded by 50% the requirements of ASME code for unfired pressure vessels, par. U-68.

Macrograph of butt-weld made by B&W Fusion-Welding Process between 6½-inch firebox plates. Note fine-grained structure and the total absence of blowholes, slag inclusions, incomplete fusion, and laps.



THE job was fabricating 6½-inch A.70 firebox plate into an unfired pressure vessel of unusual design for a highly specialized purpose. It was the kind of a job that called for ingenuity and originality from the start because of numerous complex production problems involved. Among them was butt-welding the heavy 6½-inch plates. The B&W Fusion Welding Process together with other B&W advanced techniques, produced the "weld that held." Production bend tests showed that the Fusion Welded seams withstood an elongation of 45% before tear—exceeding by 50% the requirements of ASME code for unfired pressure vessels, paragraph U-68.

It is such *extra* quality in B&W welded pressure vessels that proves the value of the 10,000 laboratory tests and studies which B&W made, starting in 1926, in the development of the B&W Fusion Welding Process.

Every inch of B&W main welds is X-ray inspected. B&W had the first million-volt X-ray unit for inspecting welds in pressure vessels on plate up to eight inches thick.

B&W welds are deposited so as to insure minimum porosity and complete absence of voids, slag inclusion, incomplete fusion and laps. B&W welding experience extends from plain carbon steels to high-tension alloys. After inspection, all pressure vessels built by B&W are stress-relieved at temperatures up to 1200 F.

From the standpoint of design, and research and manufacturing facilities—as well as for superior welding—no technical problem is ever too difficult, no fabricating job too complicated for B&W when it comes to building pressure vessels for any purpose in any size and weight that can be shipped. You can therefore bring your process equipment requirements to B&W with confidence of getting soundly engineered products of established efficiency and economy.

B&W

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
85 LIBERTY STREET, NEW YORK 6, N.Y.

POSTWAR REFINERY
DELAYED COKING
PROPANE DEASPHALTING
NAPHTHA REFORMING
FLUID CAT-CRACKER
CATALYTIC POLYMERIZATION
LUBE OIL PROCESSING
1946
JANUARY
1946
1 2 3 4 5
6 7 8 9 10 11 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
27 28 29 30 31

IN ONE SENSE . . . time and calendars have lost their despotic power over the petroleum industry.

Only yesterday the industry annihilated time . . . compressing the technological developments of a pair of decades into months so that the march to victory could be powered with a torrent of high-octane fuels and lubricated with oils equally indifferent to desert sun or arctic cold.

Today, the postwar refinery is more than a set of blueprints locked away in the company safe. Those blueprints are out on the boards . . . being altered to meet competitive conditions of the current market. In many cases, the girders and towers for new installations are already going up.

And tomorrow?

It's no secret that Kellogg process and development engineers are well along with their work on new processes. These projects have merely generic names at the moment . . . natural gas synthesis . . . desulphurization . . . hydrogenation. But they envision the possibilities of a decrease in crude supply; the necessity for more efficient utilization of poorer grade crudes; the future need for higher quality products at lower operating costs.

When you have need for these processes . . . Kellogg aims to be ready.

THE M. W. KELLOGG COMPANY

Engineers and Economists to the Petroleum Refining Industry

225 Broadway, New York 7, N. Y. • 609 Grand Avenue, Los Angeles, Cal.
Philtower Bldg., Tulsa, Okla. • 402 Esperson Building, Houston 2, Texas
Jersey City, N. J. • Stone House, Bishopsgate, London, EC2

Electrodes, Wires, Fluxes

for welding MONEL · NICKEL · INCONEL

MONEL

Oxy-Acetylene	"40" Monel Gas Welding Wire	For welding Monel, using INCO "1" Gas Welding and Brazing Flux
Oxy-Acetylene	"43" Monel Gas Welding Wire	For welding heavy sections of Monel for acid pickling service — no flux required
Metal-Arc	"130X" Monel Welding Electrode D.C.	For welding Monel; and Monel or Nickel to steel Nickel to steel
Submerged Melt.	"50" Monel Wire	For welding Monel

NICKEL

Oxy-Acetylene	"41" Nickel Gas Welding Wire	For welding of pure Nickel — no flux required
Metal-Arc	"131" Nickel Welding Electrode D.C.	For welding pure Nickel
Submerged Melt.	"51" Nickel Wire	For welding pure Nickel

INCONEL

Oxy-Acetylene	"42" Inconel Gas Welding Wire	For welding Inconel, using INCO "2" Gas Welding Flux
Metal-Arc	"132" Inconel Welding Electrode A.C.-D.C.	For welding Inconel
Submerged Melt.	"52" Inconel Wire	For welding Inconel

70/30 COPPER-NICKEL

Oxy-Acetylene	"47" 70/30 Copper-Nickel Gas Welding Wire	For welding 70/30 Copper-Nickel using INCO "1" Gas Welding and Brazing Flux
Metal-Arc	"137" 70/30 Copper-Nickel Welding Electrode D.C.	For welding 70/30 Copper-Nickel
Submerged Melt.	"57" 70/30 Copper-Nickel Wire	For welding 70/30 Copper-Nickel

"K" MONEL

Oxy-Acetylene	"44" "K" Monel Gas Welding Wire	For welding "K" Monel, using 2 parts INCO "2" Gas Welding Flux and 1 part Lithium Fluoride
Metal-Arc	"134" "K" Monel Welding Electrode D.C.	For welding "K" Monel

"L" NICKEL

Metal-Arc	"136" Nickel Welding Electrode D.C.	For welding "L" Nickel

LUKENS

NICKEL-CLAD STEEL

Metal-Arc	"131" Nickel Welding Electrode D.C.	For welding Nickel side only

"L" NICKEL-CLAD STEEL

Metal-Arc	"136" Nickel Welding Electrode D.C.	For welding "L" Nickel side only

MONEL-CLAD STEEL

Metal-Arc	"130X" Monel Welding Electrode D.C.	For welding Monel side only

INCONEL-CLAD STEEL

Metal-Arc	"133" 80/20 Nickel-Chromium Welding Electrode A.C.-D.C.	For welding Inconel side only

HARD FACING

Oxy-Acetylene	"S" Monel Hard	For corrosion-resisting, hard, non-galling overlays on low carbon cast steel. Overlays have the properties of cast "S" Monel

CAST IRON WELDING

Metal-Arc	"NI-ROD" Electrode A.C.-D.C.	For machinable welds in cast iron

FLUXES

INCO "1" Gas Welding and Brazing Flux — For the welding and brazing of Monel and other nickel-copper alloys; copper and copper-nickel.

INCO "2" Gas Welding Flux — For the welding of all stainless steels, rustless irons, Inconel and other chromium-containing alloys.

For additional information or assistance on use of Inco electrodes, wires and fluxes, address Technical Service, The International Nickel Co.

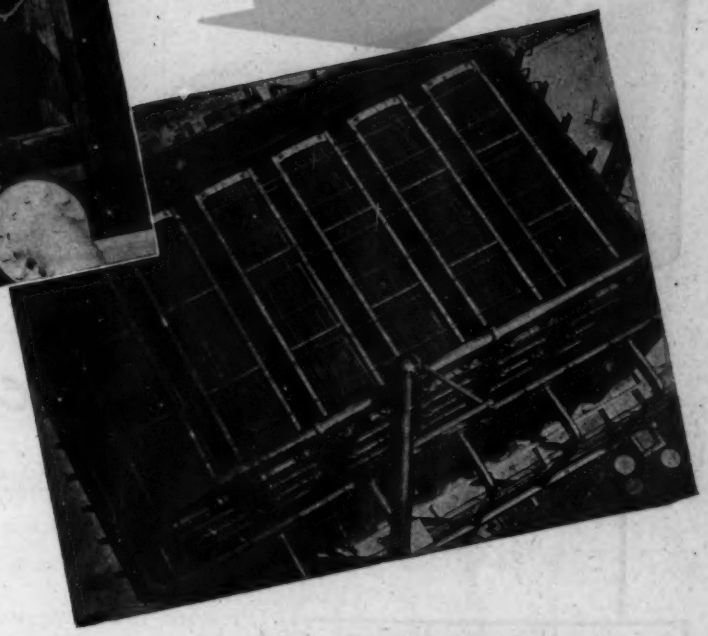
NICKEL ALLOYS

THE INTERNATIONAL NICKEL COMPANY, INC., 67 Wall St., New York 5, N.Y.

ATMOSPHERIC

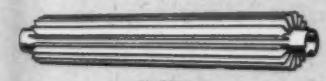
G-R BENTUBE SECTIONS

SUBMERGED

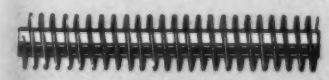


ONLY G-R BUILDS THIS WIDE VARIETY OF HEAT TRANSFER APPARATUS

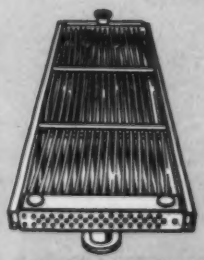
SHELL and BARE TUBE
Heaters, Coolers, Condensers, Heat Exchangers



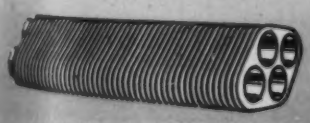
G-FIN
Longitudinal-finned elements for greater heat conductivity



K-FIN
Helical-finned elements for vapors and gases



BENTUBE SECTIONS
with scale-shedding elements for hard or salt water



TUBEFLO SECTIONS
Non-clogging design for residuum and other dirty fluids

RATINGS YOU CAN DEPEND UPON

The 8,000 G-R BENTUBE SECTIONS in service have a lengthy and extensive record of successful performance . . . condensing or cooling over six million gallons of gasoline per day . . . operating in compressor stations of pipe line systems carrying four-fifths of the natural gas used in the United States . . . installed at more than 300 refineries and natural gas companies.

The vast amount of engineering data resulting from these installations assures authoritative ratings and permits definite capacity guarantees for these units.

In addition, the proven BENTUBE SECTION superiorities of design and construction . . . their exclusive scale-shedding feature, exceptional durability, compactness, convenience of installation and economy of maintenance further warrant your investigation. Write for Bulletin 1601 describing these units in detail.

THE GRISCOM-RUSSELL CO.
285 Madison Ave., New York 17, N. Y.

GRISCOM-RUSSELL

Pioneers in Heat Transfer Apparatus

For Lower Costs with *Stainless Tubing*

...get in touch with Carpenter!

● Of course your processing problems are different. And that's just why it will pay you to put Carpenter's know-how to work in your plant. It's a sure way to cut processing costs.

Pressure, heat scale and corrosion problems are taken in stride by this tubing. And wherever strength is a factor, Carpenter Welded Stainless Tubing provides an *extra margin of safety.* Each length is 100% hydrostatically tested.

For engineering help with your corrosion, heat control and fluid handling problems, get in touch with Carpenter. Make use of our long experience with Stainless Tubing.

USE THIS SERVICE TO CUT YOUR COSTS

We have been working closely with process engineers ever since Carpenter invented the first free-machining Stainless, the first bright and ductile Stainless Strip. Put that experience to good use in your plant. Drop us a line for help with your specific problem.

And for printed help, ask for the data file folder on Carpenter Welded Stainless Tubing. It will point the way to lower costs — and trouble-free tubing installations.

CARPENTER WELDED STAINLESS TUBING

SIZES . . . . From 3/8" O. D. to 4½" O. D. Pipe sizes from 1/8" to 2".

GAUGES . . From 11 B. W. G. to 23 B. W. G.

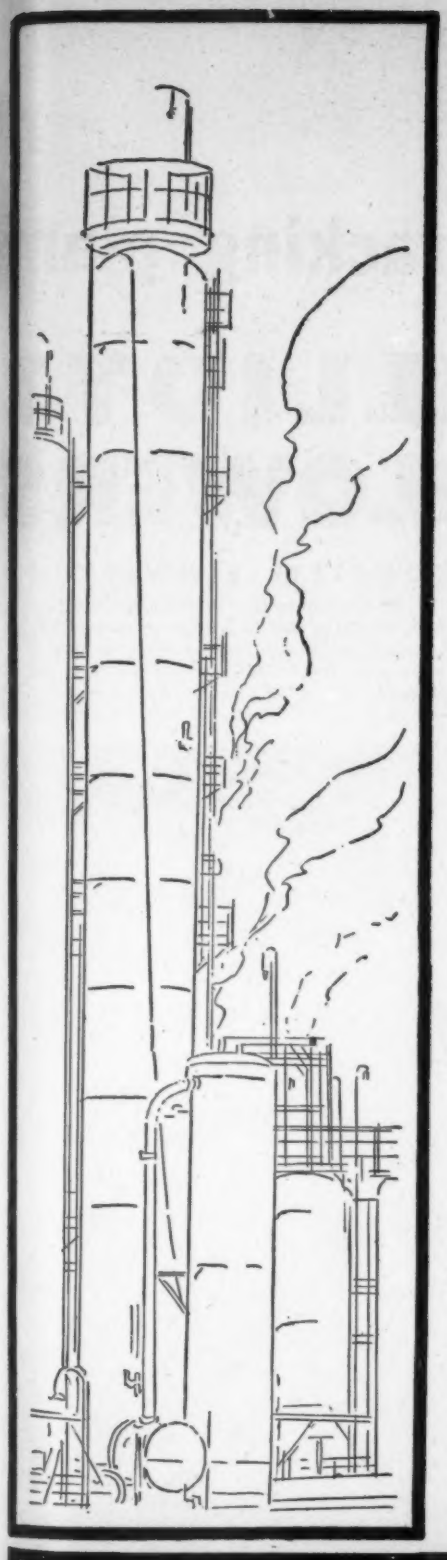
TYPES . . . . 302, 304, 347, 309S, 316, 317, 329, 430, 3-A and Invar.

SHAPES . . . Round, rectangular, oval, flat oval, half-round, drip lip, shrouded.

FINISHES . . White pickled with standard grits. Inside and outside polished tubing for special applications.

THE CARPENTER STEEL COMPANY
Welded Alloy Tube Division
Kenilworth, N. J.

Carpenter
WELDED
STAINLESS TUBING



STRATCO

PROGRESS-

Stratford cooperates with Industry in research to accomplish new developments—offers the results in the form of technical service and specialized equipment to improve existing processes.

STRATFORD ENGINEERING CORPORATION.

PETROLEUM REFINING ENGINEERS

DIERKS BLDG. KANSAS CITY, MO.

Preferred for catalytic cracking plants

Catalyst regeneration in catalytic cracking processes calls for a continuous unfailing supply of air. Many of the "cat cracker" plants get this critically important air supply from Elliott centrifugal blowers.

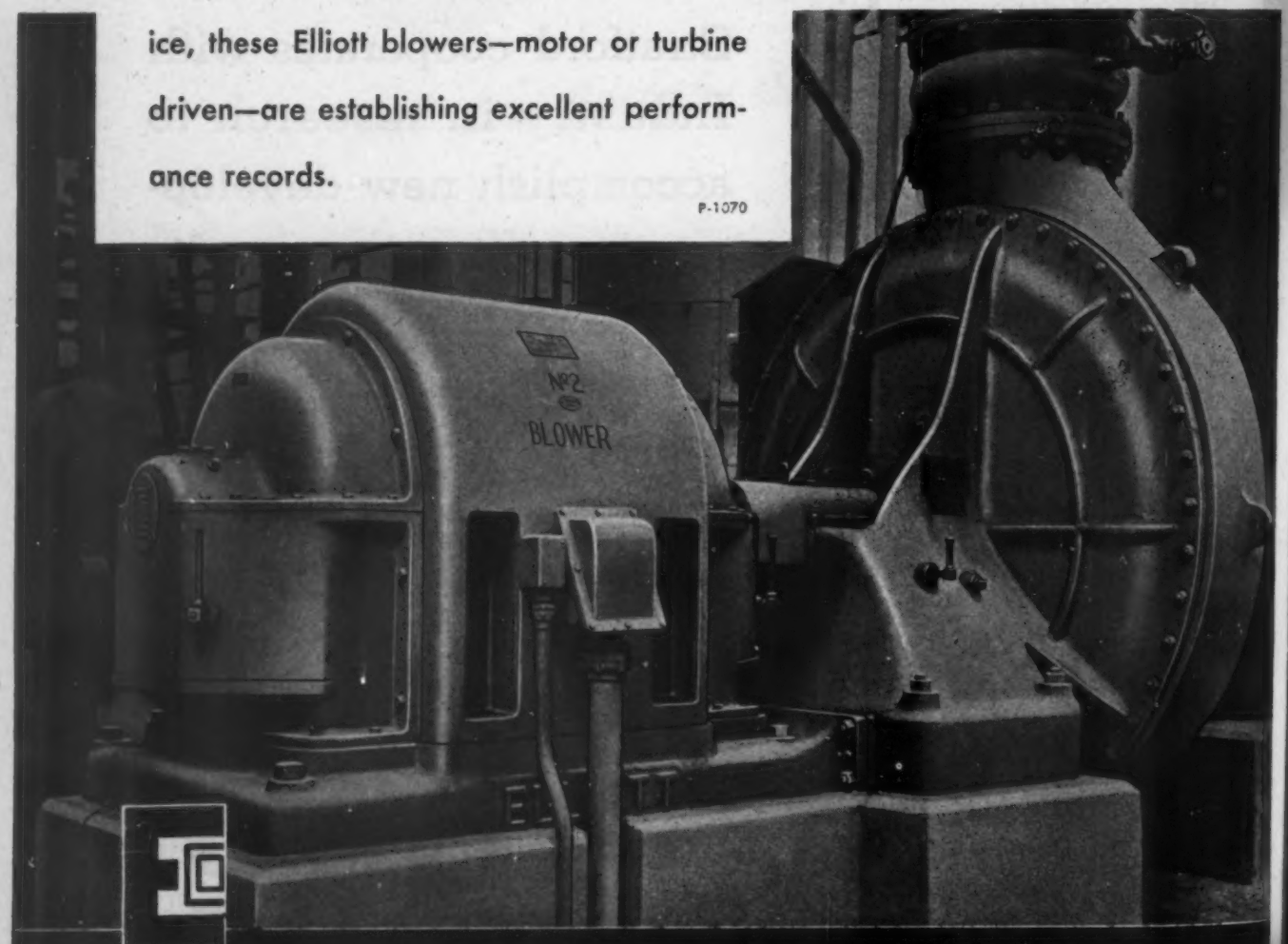
Carefully designed and built for the service, these Elliott blowers—motor or turbine driven—are establishing excellent performance records.

P-1070

ELLIOTT BLOWERS

A COMPLETE BLOWER UNIT

Elliott 21,500-cfm blower (one of three duplicate units in this plant), driven by 350-hp Elliott high-speed, 3550-rpm motor, supplies air at 2.5 psiG pressure for catalyst regeneration in the Thermofor Catalytic Cracking unit at the 10-7 plant of the Sun Oil Company in Marcus Hook, Pa. Both motor and blower are designed for outdoor operation.



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Plants at: JEANNETTE, PA. • RIDGWAY, PA.
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Kellogg engineers for years have been solving heat exchange problems encountered in various refining processes.

Engineers, specialists in heat transfer problems, in collaboration with the Kellogg chemical and physical laboratories have developed heat exchanger units which establish new thermal performance standards. The units also provide dependable, economical and trouble-free operation under difficult heat transfer conditions.

Kellogg engineers apply to the building of heat transfer equipment the original thinking, resourcefulness and sound engineering which is characteristic of The M. W. Kellogg Company's approach to all refining problems.

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2. FEWER PARTS
3. PRECISION ALIGNMENT

HIGH LIFT action of the FARRIS relief valve disc is an outstanding feature which secures high capacity discharge—for quick relief of over-pressure. This high lift also permits a more accurate adjustment of the single blow-down ring—for minimum loss of working pressure during relief action.

FEWER PARTS in FARRIS relief and safety valves is a distinctive feature of their design. Naturally, this reduces maintenance—as well as reducing the risk of failure in operation. FARRIS valves are economical—trouble-free!

PRECISION ALIGNMENT of spring, stem, disc, guide and seat, is another FARRIS achievement . . . accomplished by close tolerances on all working parts . . . justified only by the precision machining of every finished surface in a FARRIS relief or safety valve. They're safe—they're dependable!

When you have a valve problem—write to our engineering department with full details—we'll be glad to advise you, and without obligation.

FARRIS builds Safety and Relief Valves of all types, for all purposes, in all sizes. Write today for our Bulletin.

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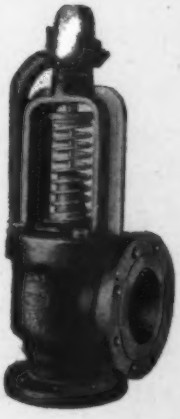

VENTURI TYPE SAFETY VALVE, Type 2150 — High velocity capacity. Steam separator, dual bearing guide. Meets ASME requirements. In steel to 600 lb., iron to 250 lb. Sizes ¾" to 6". Oversize outlets for rapid exhaust.

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WITH WESTINGHOUSE OIL-IMMERSED CONTROL

For applications in refineries where hazardous conditions and corrosive gases are present, you can't beat Westinghouse oil-immersed controls. They're built in sizes to cover the entire range of motor circuit voltages, and in various combinations of motor starting switches with or without disconnect switches.

These controls are part of a famous family—a complete line of Westinghouse electrical equipment for the petroleum industry. They'll give you safe, dependable, economical service—they're the result of *actual petroleum experience—years of it.* For complete information and expert help on your electrical problems, call your nearest Westinghouse representative. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-94682

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—Because all mechanisms are oil-immersed.

2. HAZARDOUS ATMOSPHERES
—Because the complete oil-submergence of arcing parts and connections shuts them out.

3. MOTOR OVERLOADS
—Because thermal induction relays give positive protection.

4. SHORT CIRCUITS
—Because "De-ion" Nofuze breakers isolate all faults.

5. EXPOSED LIVE PARTS
—Because breaker is interlocked to prevent energizing controller parts, except when the protective oil tank is in operating position.

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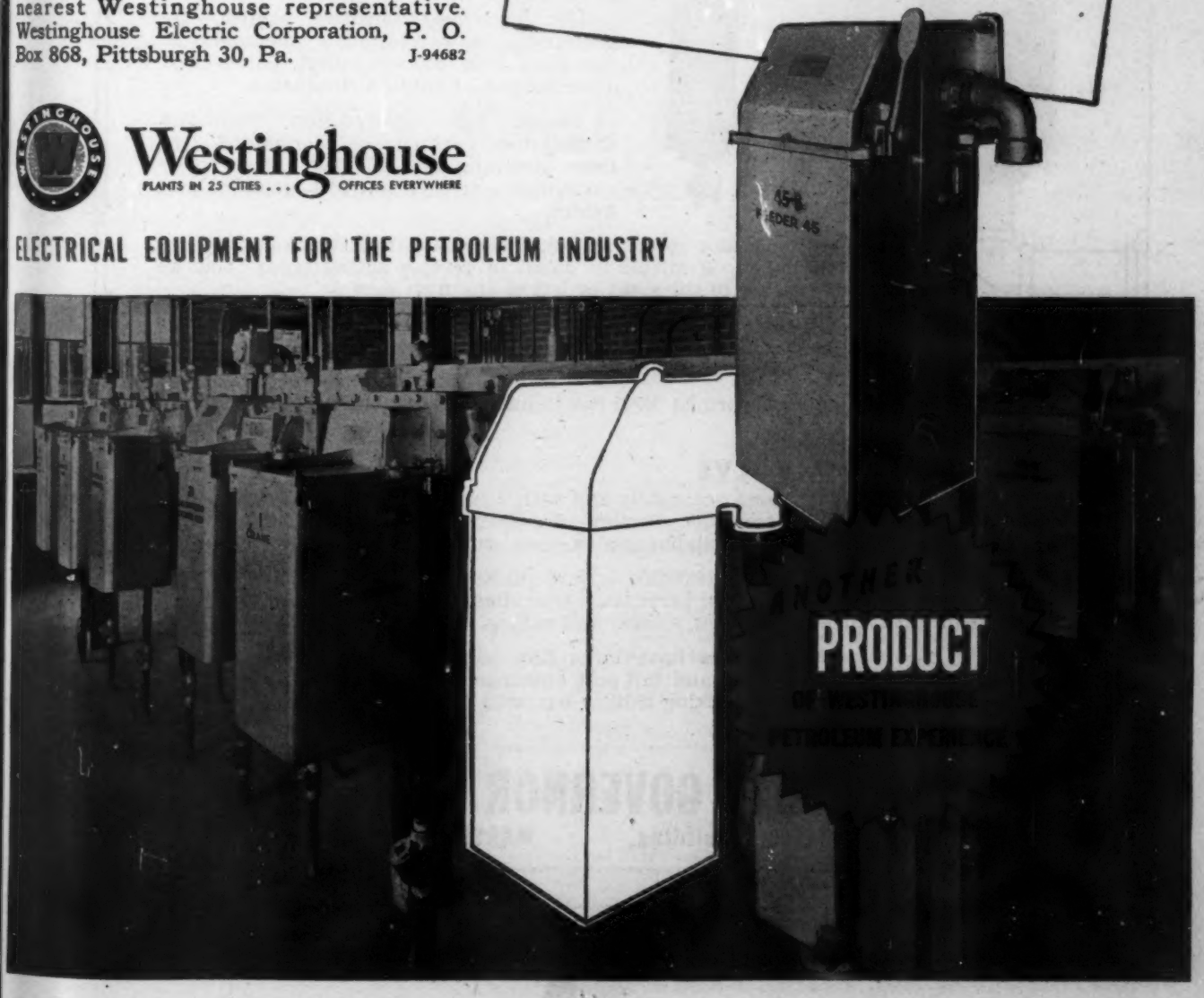

HERE'S A COMPLETE

LEVEL-TROL

HOOK-UP

A FISHER LEVEL-TROL with full throttling pneumatic pilot, actuating a remotely installed FISHER DIAPHRAGM MOTOR VALVE — a control combination that guarantees the finest in liquid level control for all fluids.

THE LEVEL-TROL

Insures extremely sensitive control — no measurable lag — pilot 100% pneumatic in operation — all linkage, pivot points and other sources of friction eliminated.

Torque tube construction eliminates stuffing box, packing and lubricator — free from gumming and sticking. Float freely suspended — free from lost motion and guides.

Relay type pilot speeds action of the diaphragm valve in response to level change. Available in direct or reverse acting types. May be mounted either to the right or left of the float cage.

Proportional band adjustment makes it possible to vary the amount of level change necessary to fully stroke the diaphragm valve — minimum level change ½", maximum change equal to length of the float.

Level position adjustment permits level maintenance at any point within the length of the float.

THE DIAPHRAGM VALVE

Correctly engineered to respond accurately and with complete dependability to the dictates of the Level-trol pilot. Performance characteristic — straight line relation between pressure to diaphragm vs. stem stroke.

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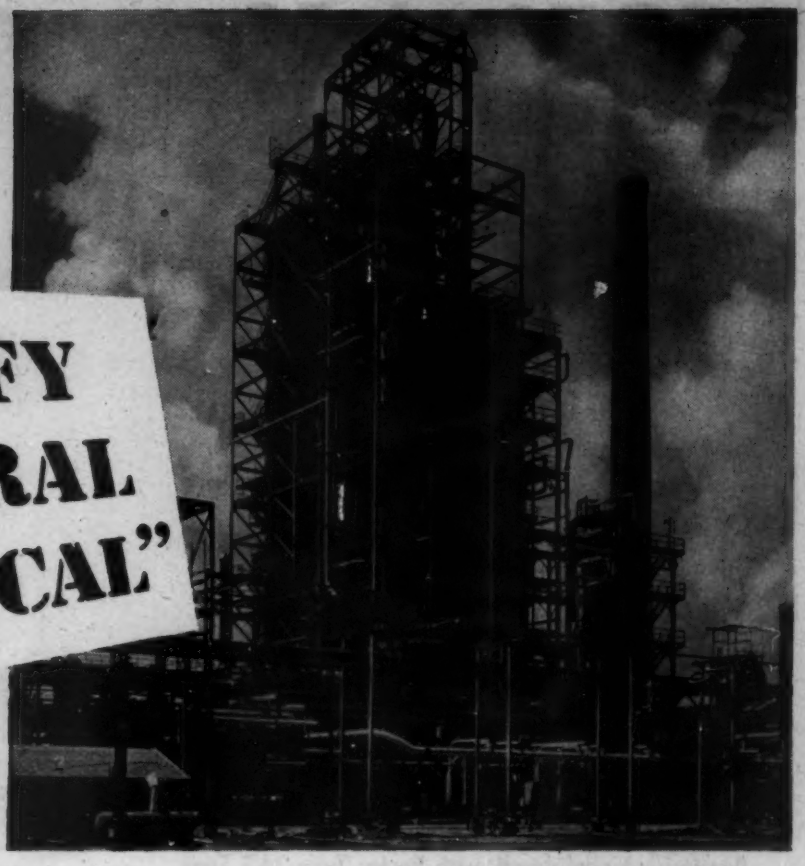

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General Chemical Company pioneered the Contact Process of sulfuric acid manufacture in this country at the turn of the century, making possible the economical production of high strength acid and thereby stimulating resultant industrial development.

Through its progressive research and advanced production techniques, General Chemical has continued to supply constantly increasing demands of the Petroleum Industry for this basic chemical down through the years ... meeting its most exacting requirements for sulfuric acid of all grades and strengths. That is why so many purchasing and operating executives specify "General Chemical" as their sources of sulfuric acid. Why not make it your choice, too.

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Standard Grade:
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15, 20, and 65% free SO_3

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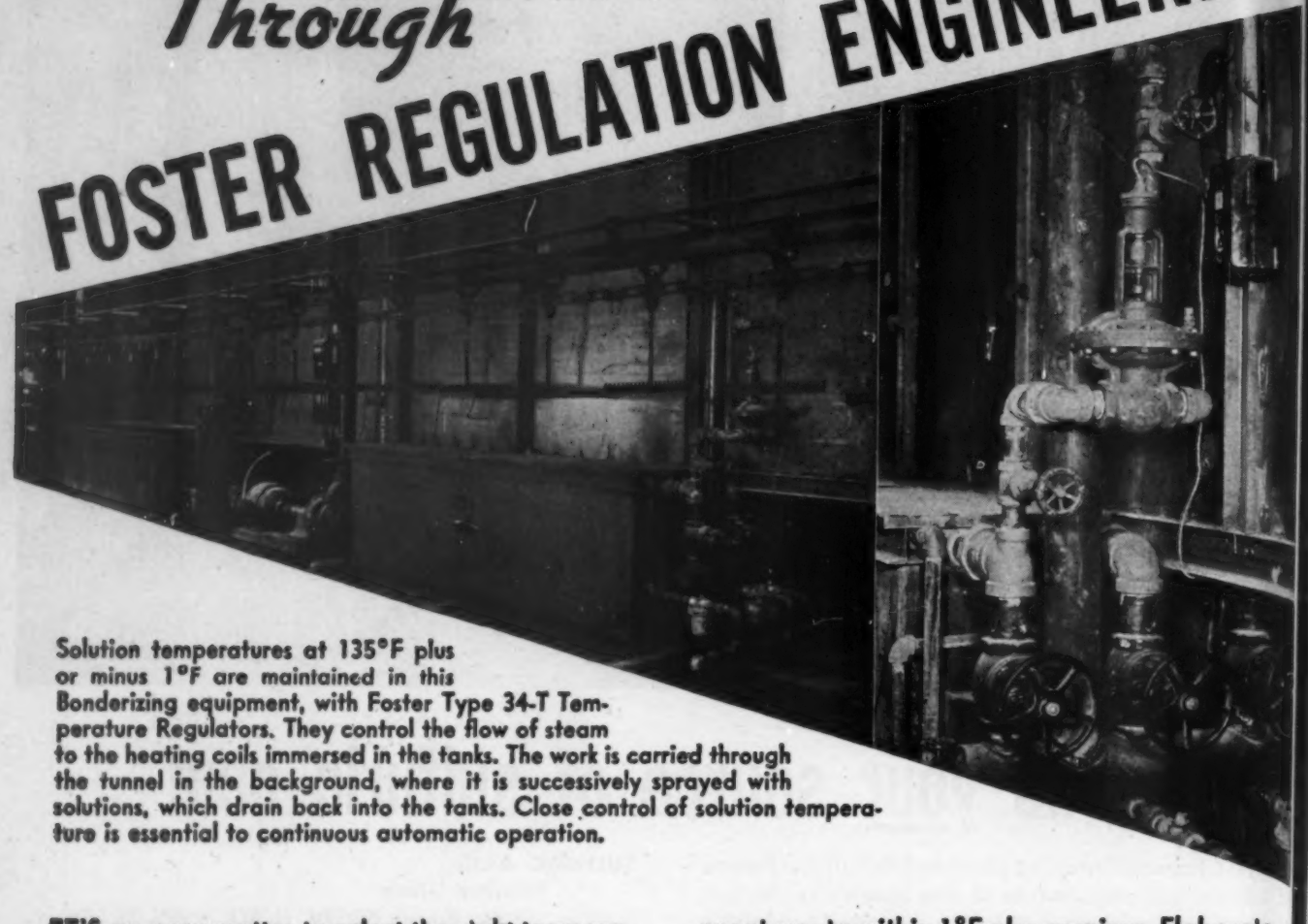
135°F ± 1°F *Through* FOSTER REGULATION ENGINEERING



Solution temperatures at 135°F plus or minus 1°F are maintained in this Bonderizing equipment, with Foster Type 34-T Temperature Regulators. They control the flow of steam to the heating coils immersed in the tanks. The work is carried through the tunnel in the background, where it is successively sprayed with solutions, which drain back into the tanks. Close control of solution temperature is essential to continuous automatic operation.

IT'S an easy matter to select the *right* temperature regulator, when you have the complete Foster line to choose from. For Foster Regulation Engineering assures the simplest trouble-free installation—by making available a temperature regulator tailored to each type of application—by selecting the one exactly fitted to your needs—and by assisting on sound installation practice.

In the Bonderizing installation illustrated, the problem was to hold solution temperatures as close to 135°F as practical without unnecessary complication. The Foster Type 34-T was selected from the entire Foster line because it is a simple basic unit capable of holding temperatures to within 1°F plus or minus. Elaborate layouts and complicated equipment were avoided, because, in this case, the 34-T fits the job.

Foster Regulation Engineering insures satisfactory performance, cuts cost and saves maintenance time.

Foster Temperature Regulators—for steam, air, liquids and gases—are available for pressures up to 450 p.s.i. and temperatures to 300°F. Temperature adjustment range of 110°F and regulation accuracy of ± 1° are available in the line. For complete details, ask for Bulletin 11.

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UNIFORM HIGH QUALITY

ALL ADD UP TO SUPERIOR PERFORMANCE RECORDS BY

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SYNTHETIC FLUID CRACKING CATALYST

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Supplies of AEROCAT, in both grades F and G, and manufactured according to specifications developed by Universal Oil Products Company, are immediately available for prompt delivery from Cyanamid's plant at Fort Worth, Texas. In addition, new AEROCAT developments are on the way.

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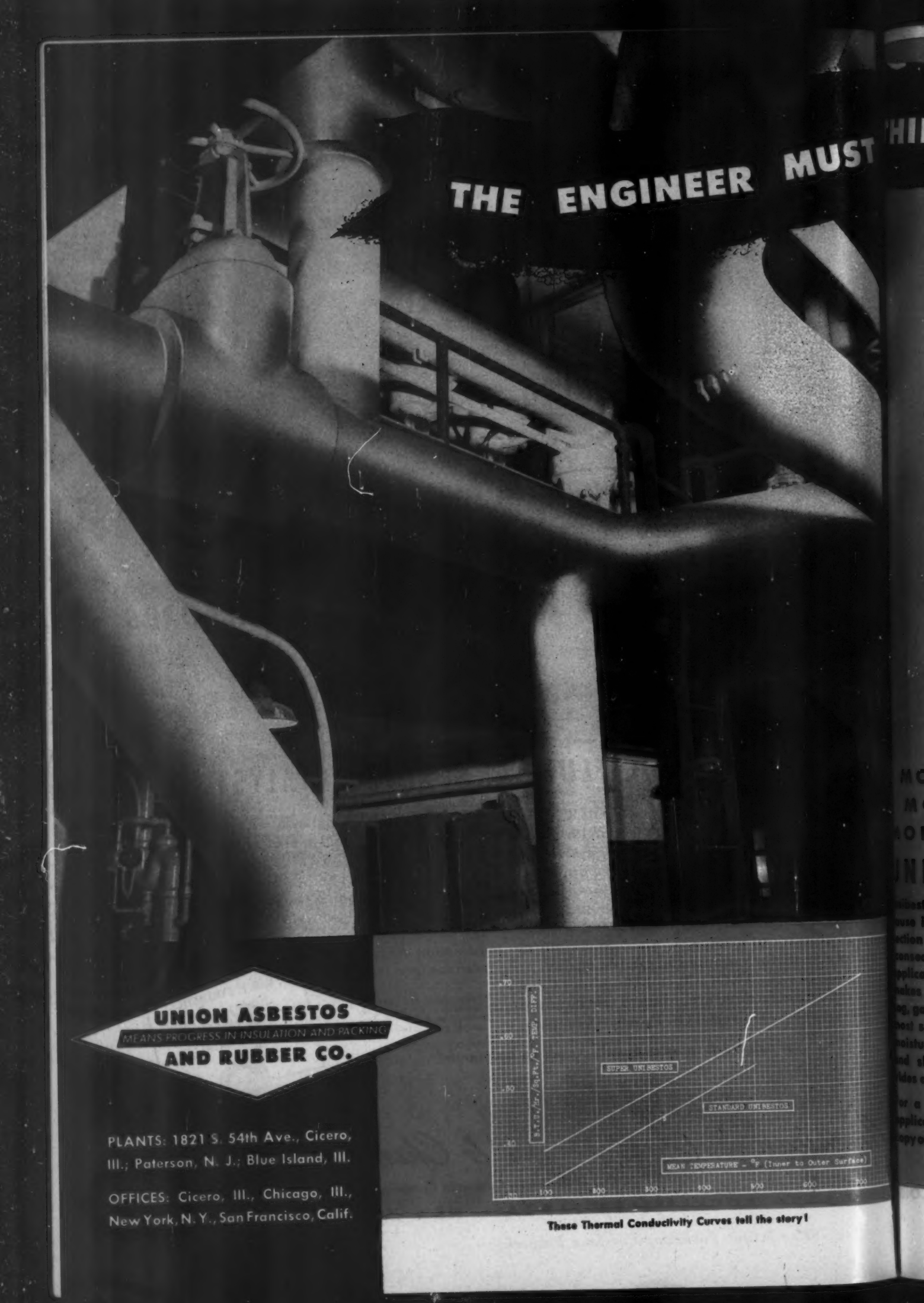

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• The rapid increase in the use of tabletted and extruded catalysts is evidence of the ever-changing developments in the petroleum industry. • Preformed catalysts are now used for: **dehydrogenation . . . hydroforming . . . hydrogenation . . . polymerization . . . dehydration . . . and other purposes.**

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TYPICAL PREFORMED CATALYSTS

Chrome	Iron	Molybdenum	Phosphates	Titanium
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Available in the Following Sizes:
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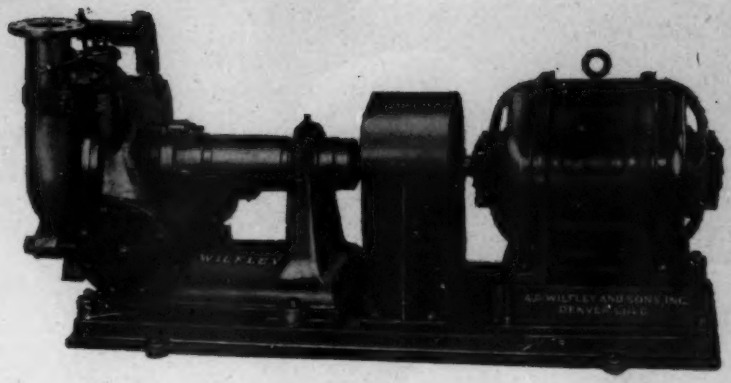

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One important reason for the outstanding performance delivered by WILFLEY pumps is the INDIVIDUAL engineering that goes with every application. Embodying exclusive features of design and construction, these pumps are characterized by a noteworthy dependability that comes from many years of pioneering, research and development in this field. Heavy pumping parts of alloy iron, alloy steel, as well as rubber when available. Write or wire for complete details.

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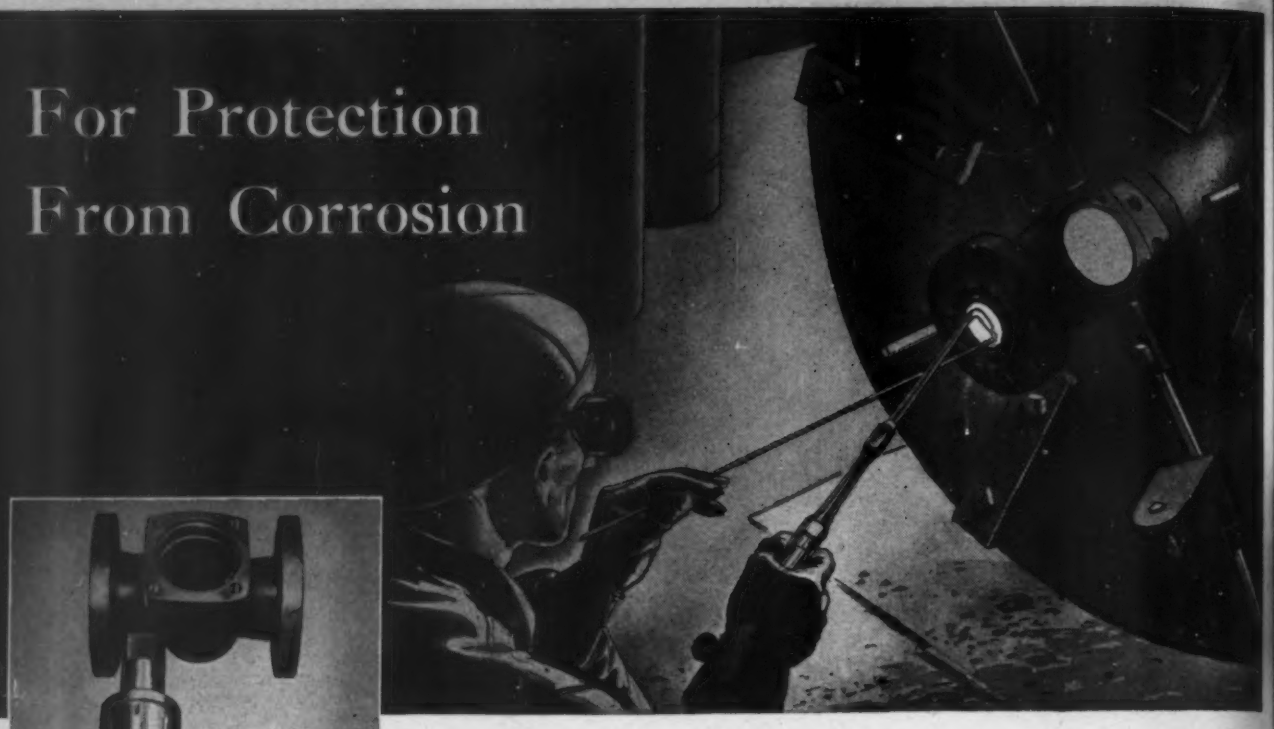
For Protection From Corrosion



The steel valve being lined with HASTELLOY *above is shown finish-ground at the left.*

Refinery Valves are HASTELLOY Faced

Steel valves last only a few days in aviation gasoline isomerization units because of the extremely corrosive materials used in processing the gasoline. When steel valves are lined with HASTELLOY, however, they give many months of uninterrupted service.

Facing with HASTELLOY nickel-base alloys is a very useful procedure for maintenance men and engineers on processes where corrosion is a problem. With HASTELLOY rod, points of corrosion can be easily covered to give them long life.

The HAYNES line includes a wide range of corrosion- and wear-resistant alloys, which make it possible to increase many times the useful life of parts subjected to corrosion or wear. Our engineers will be glad to help you develop hard-facing procedures for your product. Write for further information.

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You Can Get Facing Rods of These HAYNES Alloys.

For Resistance to Wear and Heat...
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For High Hardness...
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For High Resistance to Impact...
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For Utmost Resistance to Abrasion...
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For Resistance to Heat and Corrosion...
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Peak Performance

Assured by Controlled Quality

Peak performance is assured in Ladish Forged Steel Flanges by the exacting metallurgical control which safeguards quality at every step in manufacture.

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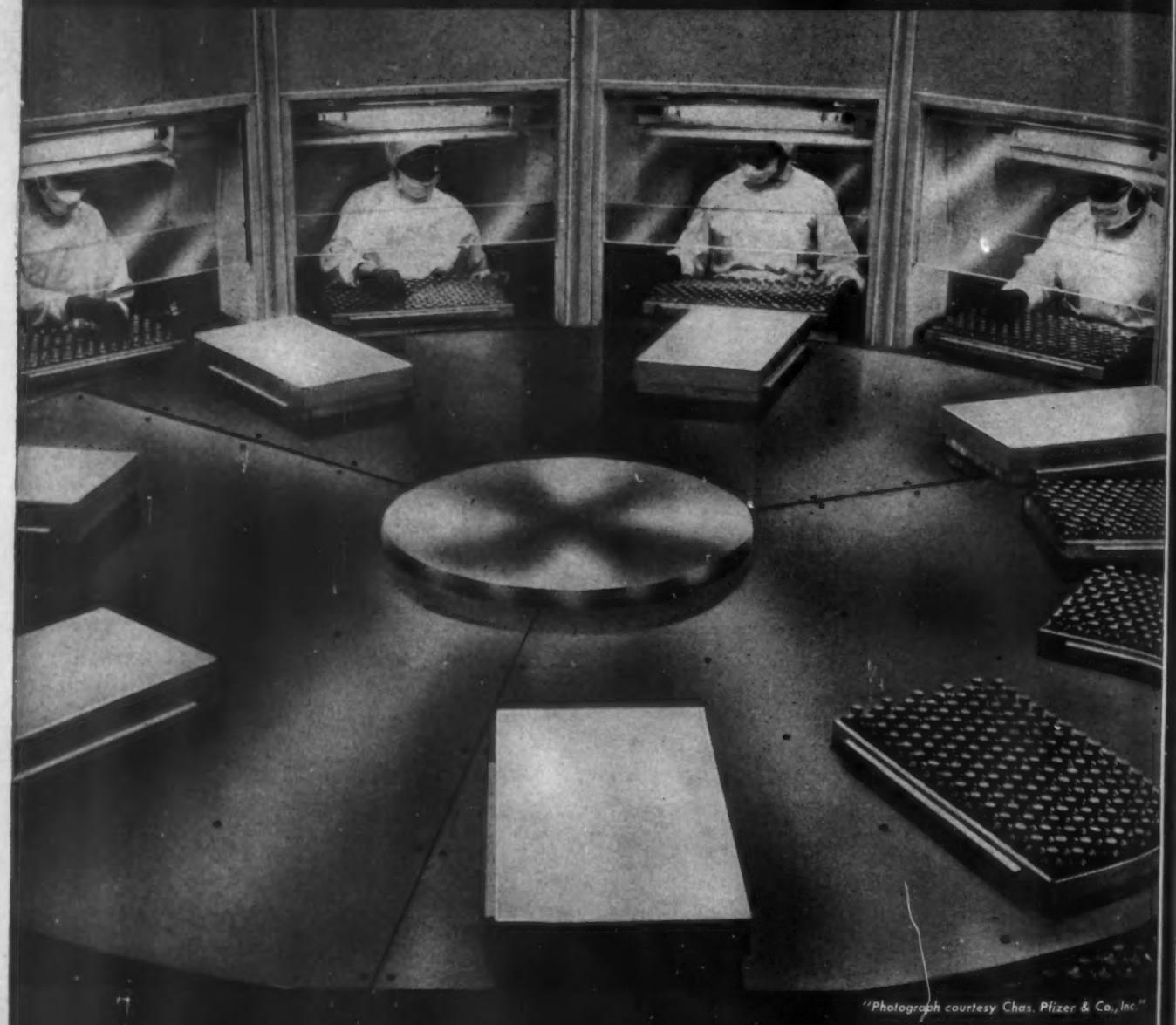

"Photograph courtesy Chas. Pfizer & Co., Inc."

Packaging the miracle drug... penicillin... calls for completely sterile conditions. Here the table must be the very acme of aseptic cleanliness... easy to clean and keep clean. Hence, it's chromium-Nickel stainless steel.

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International Nickel are miners, smelters and refiners of Nickel, an important ingredient of the stainless steels, but do not produce stainless steels. If interested, please communicate with your established sources of supply for stainless steels.

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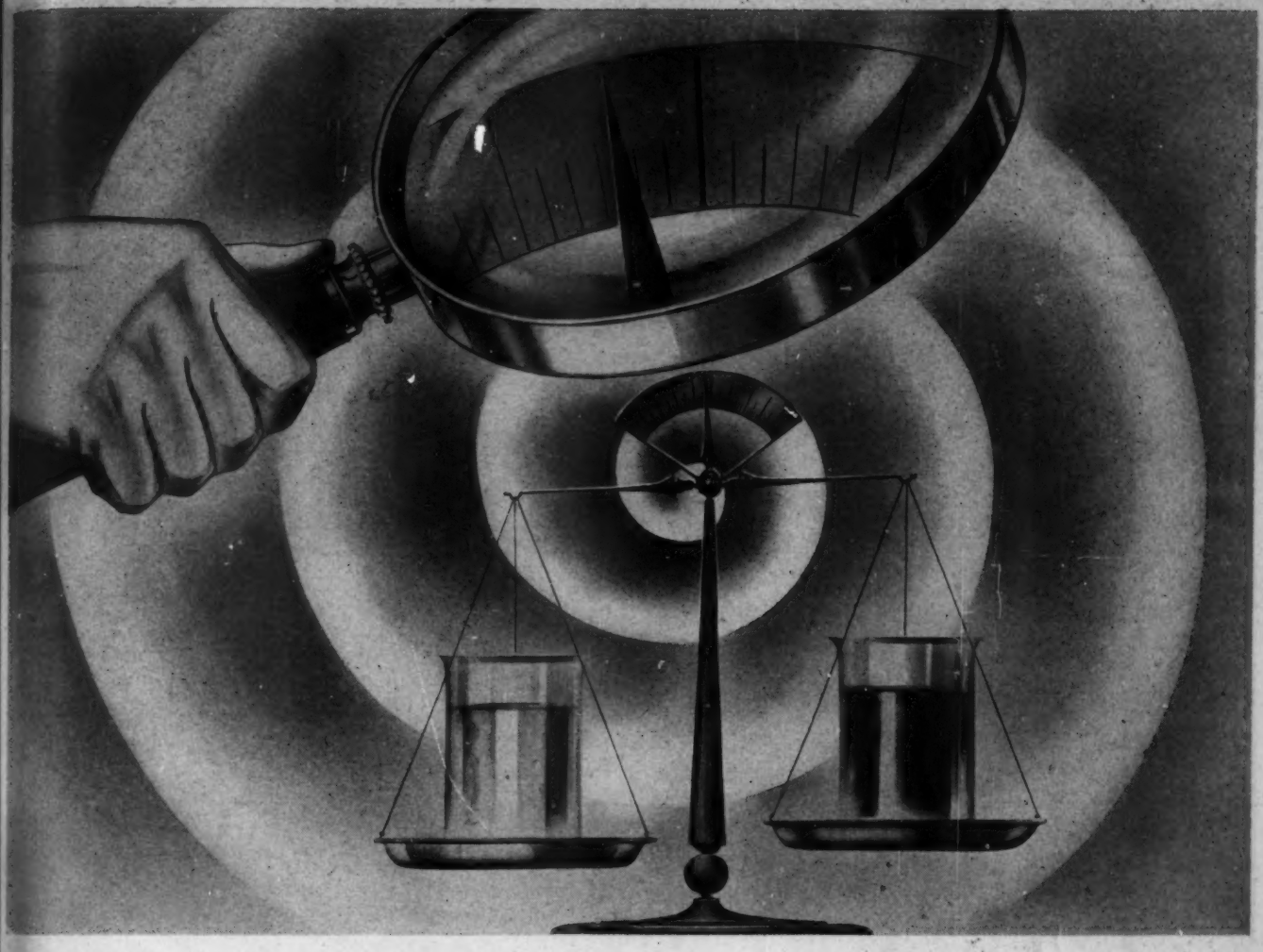

IT MAGNIFIES THE DIFFERENCE

Where the difference in specific gravity of materials is close, separation by gravity settling may be impossible, but even in cases where the difference is enough to permit gravity settling, the separation at best will be slow and incomplete.

Applied centrifugal force greatly multiplies specific gravity differences. The greater the force brought to bear, the greater those differences become.

SHARPLES SUPER-CENTRIFUGES generate a force tremendously greater than gravity and stubborn mixtures of materials, no longer able to resist, separate quickly and effectively.

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Tight fits in tight spots . . . another investment in J-M Insulations that is destined to pay off as planned.

. . . their skill is your protection against the pitfalls of poorly applied insulation

PITFALLS in insulation application are many —and costly. Costly in money through wasted fuel . . . costly in operating efficiency through inadequate heat control.

To assure proper application of its insulating materials, Johns-Manville recommends the engineering skill and expert workmanship of organizations especially set up for this work. In some areas the groups are Johns-Manville's own construction forces. In others, they are J-M Technical Service Units—contracting companies carefully selected for their integrity and background in this field. Each of these organizations is responsible for handling all details of an insulation job—a complete carry-through from planning to application.

Through generations of research, Johns-Manville has developed a line of insulations that spans the entire range of industrial temperatures and fits every service requirement.

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If you have an insulation problem, why not call on J-M for the solution? Write Johns-Manville, 22 East 40th St., New York 16, N. Y.

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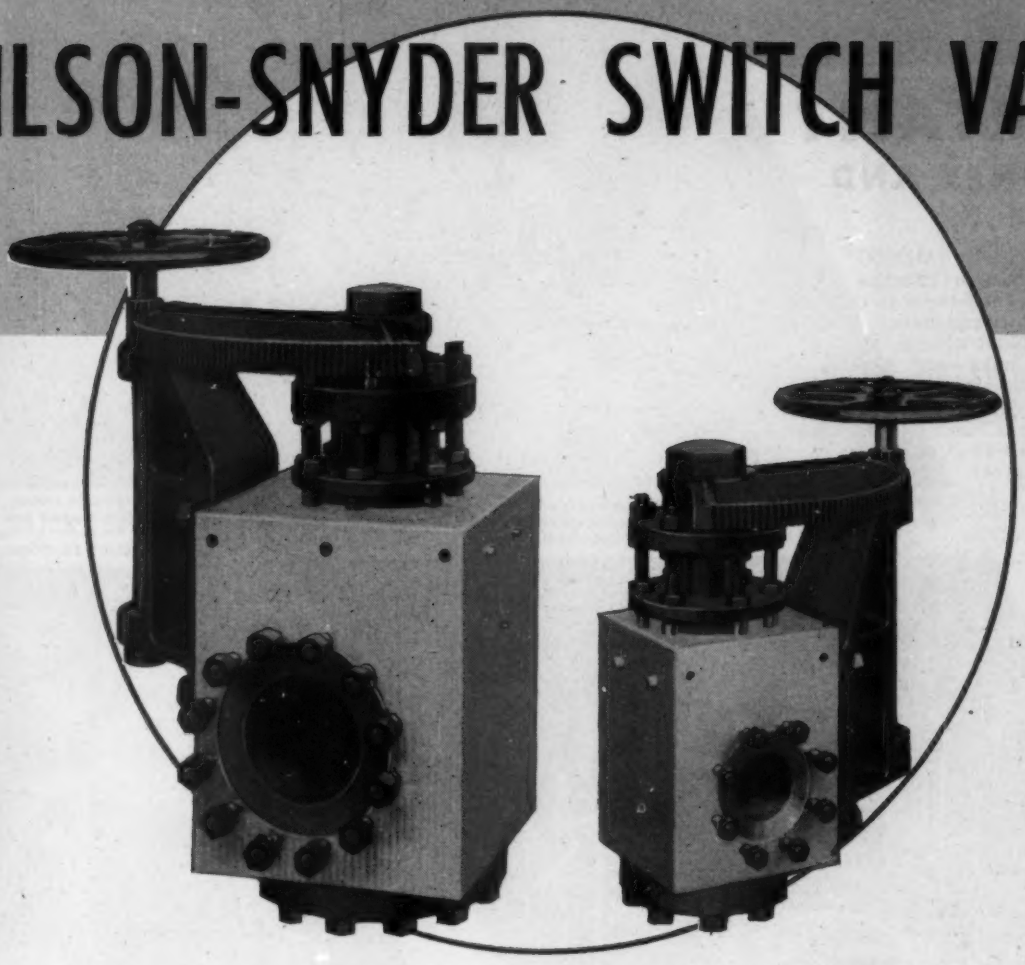
JOHNS-MANVILLE *First in* **INSULATIONS**

FOR UNINTERRUPTED HOT-STREAM CONTROL IN REFINING PROCESSES

WILSON-SNYDER SWITCH VALVES



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FOR switching flow of hot liquids or vapors from one processing chamber to another—

1. Without interruption of continuous flow.
2. Without delay due to "coking up"—minimum possibility for coking and positive provision for quick breakage of coke seal.

Single inlet, 2, 3, or 4 outlets.

(For some applications reverse hookup possible, resulting in multiple inlets and single outlet.)

3″ to 10″ sizes built and in service on continuous coking units—
Temperature up to 1100 degrees F.
Pressures up to 600 p.s.i.
Connections to suit purchaser's standard.

Inquiry concerning your Hot Stream Control problem will receive immediate attention at any of the following offices:

WILSON-SNYDER MANUFACTURING DIVISION

OIL WELL SUPPLY COMPANY

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949 MELLIE ESPERSON BLDG., HOUSTON 1, TEXAS
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UNITED STATES STEEL

Process Adapted Agitation

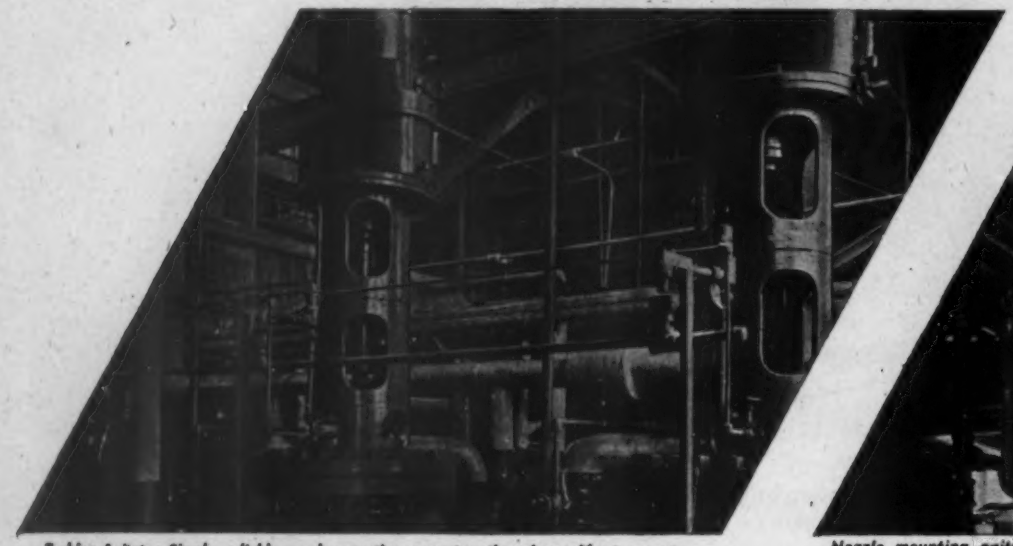
IMPORTANT

SAVE MONEY AND TIME...

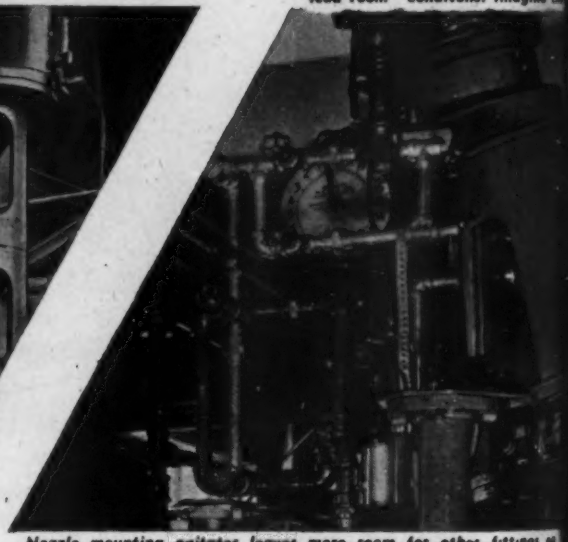
Note illustrations carefully *"MIXCO"* and *"LIGHTNIN"* Agitators offer the only complete line of self-supporting—nozzle mounting equipment. Nothing else to buy. No structural steel to design and make—any pipe fitter can attach to tank in a few minutes. Easily removable for use elsewhere. Turbines designed to assemble through small openings.

Nozzle mounting propeller-type agitator mounted in off-center position. Needs no baffles—permits freedom of head design. Sanitary construction—used in Blood Plasma production. Simplified installation—no external supports.

Simple side branch pipe adapter provides support and closure combined for Agitator used under "[illegible] head room" conditions. Imagine the

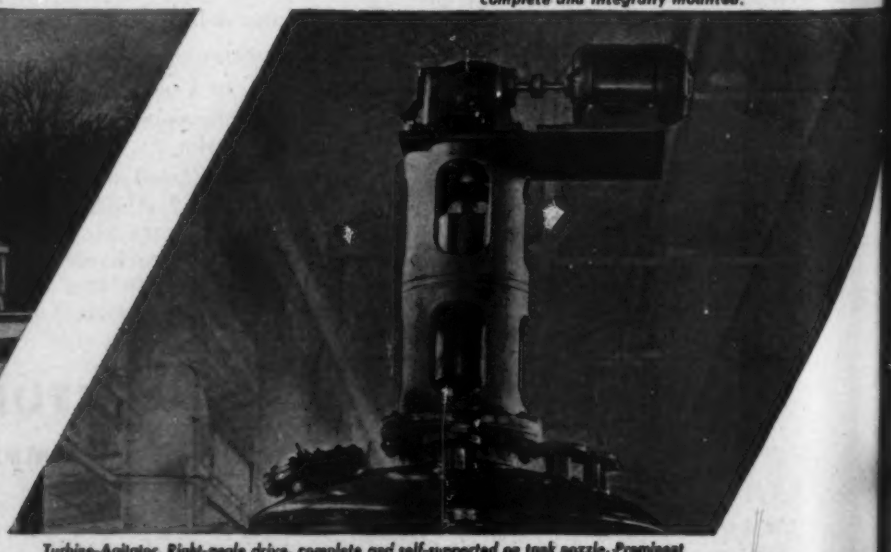


Turbine-Agitator. Simple, reliable nozzle mounting supports entire mixer without separate structural steel. Factory aligned—integral construction assures proper stuffing box performance on this difficult high pressure job.



Nozzle mounting agitator leaves more room for other fittings on vessel head. Note how structural steel supports would have complicated piping layout and increased head room, if mixer were not complete and integrally mounted.

For outdoor service, self-supporting, nozzle mounting agitators pay extra dividends in lower overall cost, lower maintenance and simplified, accessible installations.



Turbine-Agitator. Right-angle drive, complete and self-supported on tank nozzle. Prominent process vessel builder appreciates integral construction with stuffing box already aligned and unit ready to install. Note: designer has been able to locate all other fittings without interference with usual structural steel supports.

. . . for Pressure Vessels

Self-Supporting, Factory-Assembled and Permanently Aligned

TOP ENTERING MIXERS

Where to use them. In problems involving mixing under pressure, vacuum, airtight, vapor proof and other similar conditions, a Top Entering *"LIGHTNIN"* or *"MIXCO"* Agitator—*properly engineered for the specific job*—is the answer. Because the operation takes place in a closed tank, the agitation must be fitted to the job with due consideration for all factors including tank size, viscosity of materials, results required, etc., etc.

"LIGHTNIN" and *"MIXCO"* Top Entering Agitators are available in ¼ to 50 H.P. direct or gear drive for agitating liquids up to 20000 centipoises at mixing temperature. A wide variety of propellers and turbine type impellers are available to give maximum efficiency on various materials under a specific set of conditions and requirements.

TOP ENTERING MIXERS—A wide range of sizes for large or small tanks—¼ to 50 H.P. for vertical use on pressure or vacuum vessels. Integral mounting, all impeller types, Radial Turbines and propellers.

Illustration above for open tanks.

PORTABLE MIXERS.—½ to 10 H.P. for rim attachments to open tanks. Gear and direct drives. Many exclusive conveniences. Off-center positioning. Extended bearing sealed against oil and grease leaks.

SIDE ENTERING MIXERS.—1 to 25 H.P. for horizontal use. Any size tank. Propeller type only. Many models and drives. In use on tanks up to 5,000,000 gallons capacity.

The Basis of Our Recommendations

Twenty-five years of experience have resulted in an organization, research facilities and skill which qualify Mixing Equipment Company as a leading authority in the whole broad field of agitation.

Mixing Equipment Company offers its services in the solution of any problem involving controlled recirculation of liquids to produce physical and chemical changes, as included in the following table:

Blending Miscible Liquids	Mixing Immiscible Liquids	Crystal Size Control	Gas Absorption and Dispersion	Suspension of Solids	Heat Transfer
Simple Mixing of soluble liquids as in reducing concentration	Washing of Liquids Extraction Contacting Caustic Treating Emulsions	Precipitation Evaporation Systems	Hydrogenation Aeration Gas Scrubbing Chlorination Gas Washing	Slurries Slaking Lime Suspension of: filter aid, activated carbon, Fullers Earth, Crystals while dissolving	Stills Evaporators Reactor Vessels Heating Cooling

Mixing Equipment Co. Offers

Complete coverage of industrial areas with service for both individual user and engineers or equipment manufacturer.

Assumption of responsibility for selection of mixer size, types, performance characteristics within limits of existing technology.

MIXING EQUIPMENT CO., INC.
1064 Garson Avenue
Rochester 9, New York

TOP-ENTERING LIGHTNIN PORTABLE MIXCO SIDE-ENTERING

MIXING EQUIPMENT CO., INC.
1064 GARSON AVENUE, ROCHESTER 9, N. Y.

Please send me the literature checked:

- ☐ B-66 and B-76 Side Entering Mixers
- ☐ B-78 Pressure Vessel Mixers continuous or batch
- ☐ Mi-15—Refinery Applications
- ☐ Mi-16—Questions and answers—gasoline blending
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Name_____

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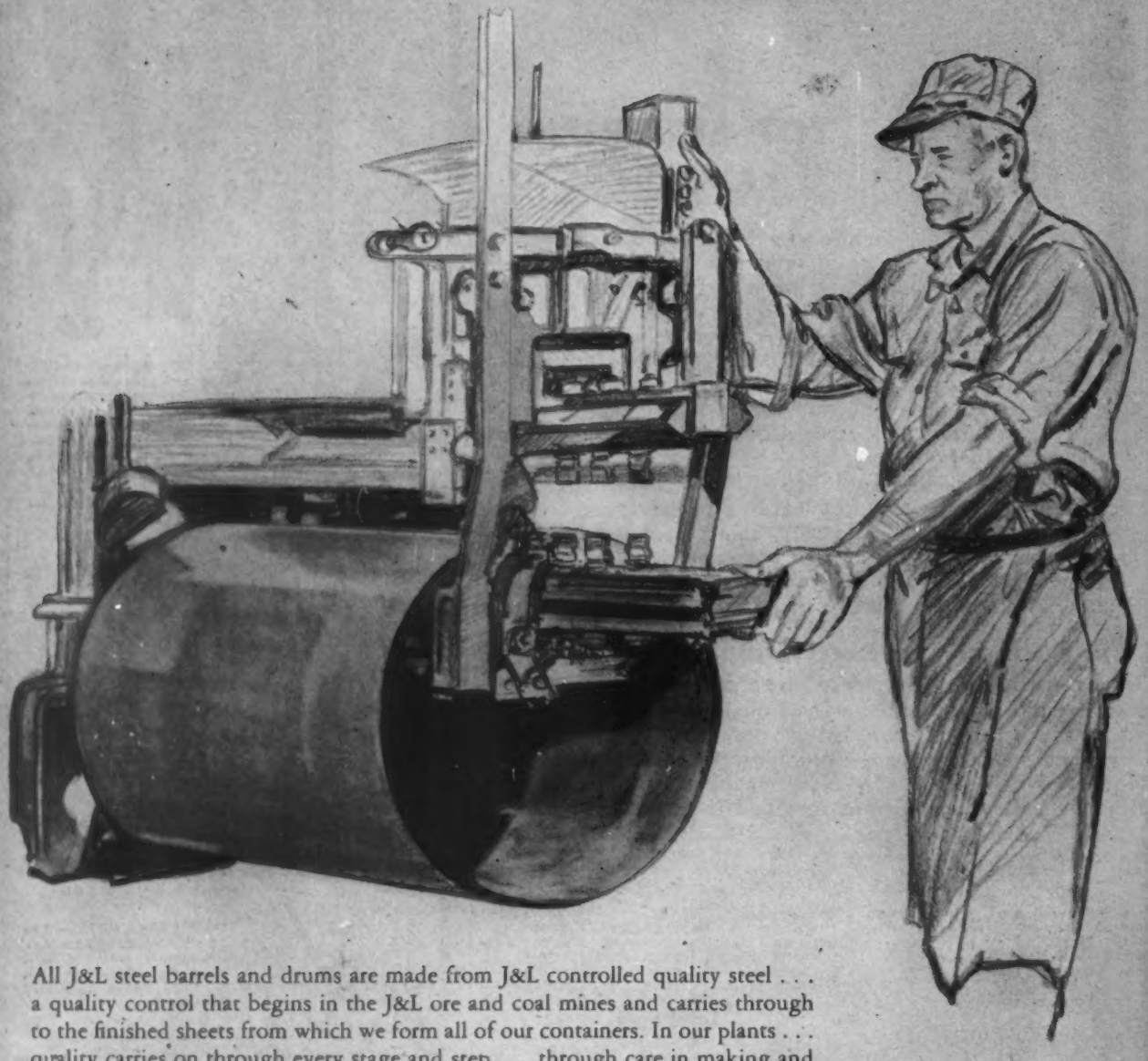
THE BETTER THE STEEL—
THE BETTER THE DRUM



All J&L steel barrels and drums are made from J&L controlled quality steel . . . a quality control that begins in the J&L ore and coal mines and carries through to the finished sheets from which we form all of our containers. In our plants . . . quality carries on through every stage and step . . . through care in making and rigid inspection. Every J&L drum and barrel you buy can trace its history right back to original material and sources. It is a pedigreed product. It is made to serve you and serve you well. We invite your inquiries and your orders.

Ship in Safety • Ship in Steel

J & L STEEL BARREL COMPANY

A SUBSIDIARY OF JONES & LAUGHLIN STEEL CORPORATION

PITTSBURGH 30, PA.

PLANTS:

BAYONNE, N. J. • CLEVELAND, OHIO • LAKE CHARLES, LA. • NEW ORLEANS (GRETNA), LA.
NO. KANSAS CITY, MO. • PHILADELPHIA, PA. • PORT ARTHUR, TEXAS • ST. LOUIS, MO.

MASTER GEARHEAD MOTORS

COST REDUCED by the elimination of bearings, couplings, chains, and sprockets, gear trains or separate gear reducers . . . only one unit to mount . . . lower assembly costs.

COMPACT. High reduction ratios secured in small space by using heat treated special alloy steels for both splined shafts and gears.

HIGHER EFFICIENCY than other types of slow speed drives . . . only 2 percent power loss in each stage of gear reduction, in parallel shaft types.

SIMPLIFIED DESIGN. More compact . . . less weight . . . permanent alignment . . . fewer moving parts . . . high efficiency . . . longer, reliable, trouble-free operation.

INTEGRAL CONSTRUCTION. Both motors and gears are designed, built, and guaranteed by one organization as a well balanced power package.

AVAILABLE FOR EVERY TYPE current specification . . . every type enclosure . . . every type mounting arrangement . . . the most flexible line of gearhead motors in the world. This wide flexibility makes it easier to secure exactly the right drive for each installation.

ANTI-FRICTION BEARINGS are used throughout the entire unit.

100 HORSEPOWER AND SMALLER

THE MASTER ELECTRIC COMPANY • DAYTON 1, OHIO

NO "GLAND TROUBLE"

Because UNITROL level Controller has no packing glands or stuffing box

On recirculator systems of condenser hotwells, deaerators—or wherever the level of liquids must be controlled—UNITROL will do it more accurately! Simple . . . self-contained . . . this exclusive design eliminates trouble-making restrictive elements. Friction is minimized. Action is free and unhampered. Feed or drain is regulated promptly and positively. The float is linked to the inner valve through ratio connection, with maximum float travel on any size valve of only 7 inches. Available for temperatures up to 750° F.—in valve sizes ½" to 4"—integral casting construction—valve and float-cage of semi-steel or cast steel—float of seamless copper or stainless steel—and with the fine craftsmanship for which K & M has been recognized for 75 years. Our Engineering Department will be glad to make specific recommendations.

Write for Catalog 66c

KIELEY & MUELLER, INC.
MANUFACTURERS OF PRESSURE AND LEVEL CONTROLS
2005-43RD ST., NORTH BERGEN, N. J.

Awarded our employees for outstanding production achievement

Call BETHLEHEM SUPPLY for

STEEL TUBES

BRONZE TUBES

FINTUBES

Next time there's a hurry-up tube job on heat exchangers, coolers, condensers, tube stills, or boilers, give our nearest store an inquiry by phone or wire. You'll find we can help with the following tubular products:

Steel tubes—Hot-finished or cold-drawn seamless; made of any of the standard tubular steels or alloys to most of the applicable ASTM specifications. Also available: exchanger and boiler tubes to ASTM specifications.

Non-ferrous tubes—Arsenical Admiralty, Duronze IV, Duronze V, Cupro-Nickel, Cuzinal, Red Brass, and Duplex.

Brown Fintubes—Tubes and fins available in steel and its alloys, Admiralty metal, or combinations of steel and bronze. Corrosion-resistant . . . nominal cost . . . wide range of sizes.

With any or all of these high-quality products, Bethlehem Supply offers expert engineering and metallurgical service—and prompt attention to your orders. *There's* a combination that's hard to beat!

Bethlehem Supply Offices or Stores: **Arkansas**—Magnolia; **Colorado**—Craig; **Illinois**—Grayville, Salem; **Kansas**—Chase, Great Bend, Pratt, Russell, *Wichita; **Louisiana**—Harvey, Houma, Lake Charles, New Iberia, Shreveport; **Mississippi**—Laurel; **New Mexico**—Artesia, Hobbs; **Oklahoma**—Oklahoma City, *Ponca City, Seminole, Tulsa, Wewoka; **Texas**—Alice, *Amarillo, *Beaumont, Borger, Bowie, Corpus Christi, *Corsicana, *Dallas, *Fort Worth, Graham, Houston, Kermit, Kilgore, La Ward, McAllen, Odessa, Pampa, *San Antonio, Sundown, Wichita Falls, Winnsboro. (****Office only.***)

BETHLEHEM SUPPLY COMPANY
Subsidiary of Bethlehem Steel Corporation

BETHLEHEM STEEL

GHQ FOR REFINERY SUPPLIES

ASBESTOS IN ACTION
WITHSTOOD BOTH
HURRICANE
and
FIRE!

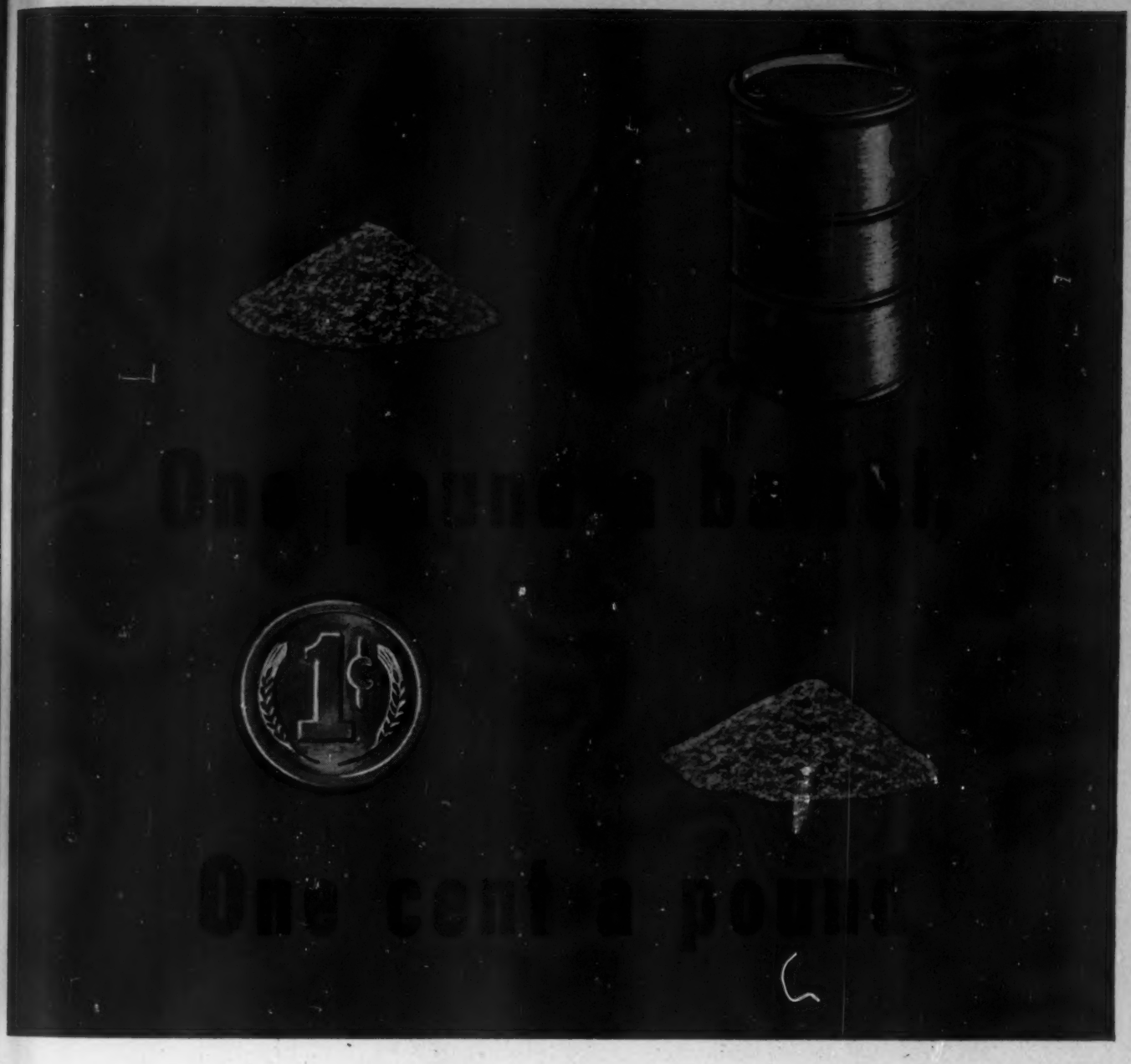
BETTER THAN we had anticipated . . . the outstanding performance of K&M "Century" APAC used as sheathing on the hangar doors of the Richmond, Fla., Naval Air Station. While the hangars themselves were completely destroyed by the fire and hurricane of September 16th, the *doors remain intact.* On-the-scene estimates indicate that *only* 5% of the APAC sheets were damaged . . . necessitating repairs of a very minor nature, considering the magnitude of the disaster. LET THIS OUTSTANDING BUILDING MATERIAL GO TO WORK FOR YOU.

ASBESTOS IN ACTION
HIGH, WIDE and HANDSOME!
. . . and SAFE because it's sheathed with "Century" APAC
THE striking architecture of this Navy Blimp hangar is its own tribute! The doors are like skyscrapers 120 feet high weighing 300 tons. And they must open the entire width of the hangar in TWO MINUTES.
These giant portals must be the masters of wind and weather—for failure to open and close quickly might spell the doom of a wind-tossed Blimp. So they are completely sheathed with "Century" Apac—K&M's low cost asbestos-cement sheet material. It is rot-proof, rust-proof and fire-resistant.
In thousands of industrial plants, K&M "Century" Apac is used for roofing and siding, office paneling, sheathing on machine shops and stock rooms, linings for elevator casings and shower stalls. It is ideal for new construction, repairs or plant additions.
Enormous quantities of "Century" Apac have gone into wartime jobs. YET NOW THERE'S PLENTY AVAILABLE FOR YOUR INDUSTRIAL CONSTRUCTION WORK . . without delay, without restrictions.
Nature made Asbestos
KEASBEY & MATTISON
COMPANY · AMBLER · PENNSYLVANIA

This advertisement originally appeared in April 1945

KEASBEY & MATTISON
COMPANY · AMBLER · PENNSYLVANIA

K&M best in asbestos

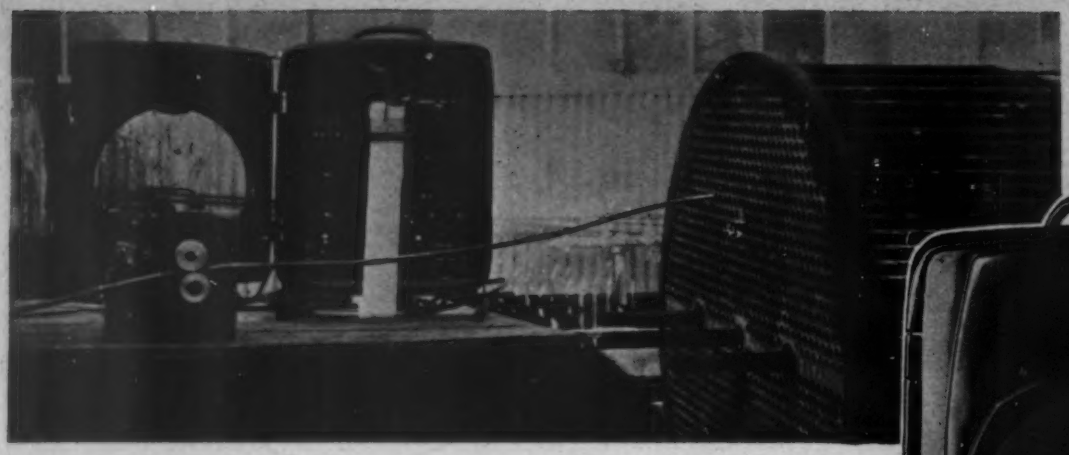


● It's as easy as that to figure the cost of adsorbent when Fullers Earth is used in the percolation finishing of high-quality oil. Fullers Earth can be regenerated and reused time after time. Approximately one pound of fresh adsorbent is needed for each barrel of oil finished—and the cost of percolation grade Fullers Earth runs about a cent a pound. The total cost of finishing oil that has been pre-refined by such modern methods as solvent-deasphaltizing and de-resining is only 12 to 16c a barrel—much less than the cost of adsorbent alone in other clay finishing processes.

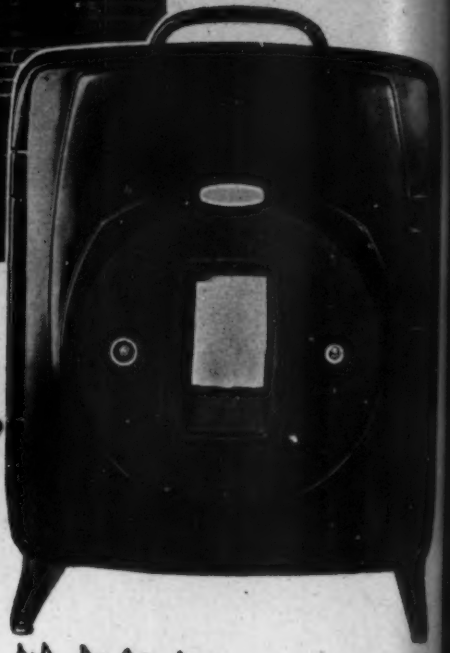
Proof of the value of percolation finishing is the fact this low-cost method is chosen for highly refined crystalline waxes and petrolatums, medicinal oils and other petroleum products that must meet the most rigid specifications. Oils finished by this method have better color and oxidation stability, lower carbon residue and better demulsifying characteristics.

Refiners planning to expand their plants or build new ones will want complete facts on modern percolation finishing. Our long experience with the process can be helpful in projecting such plans. The advice and help of our research and engineering staff are available without obligation.

ATTAPULGUS CLAY COMPANY
260 SOUTH BROAD STREET • PHILADELPHIA 1, PENNSYLVANIA
EXCLUSIVE SALES AGENT: POROCEL CORPORATION



Probolog in use inspecting tube bundle. Picture shows probe in tube, probe puller withdrawing probe at constant rate, and recording instrument charting internal tube condition.



HERE'S A NEW WAY TO

LOOK FOR TROUBLE!

THE PROBOLOG is an inspection device for testing non-magnetic tubes *without removing them from the equipment in which they are installed.*

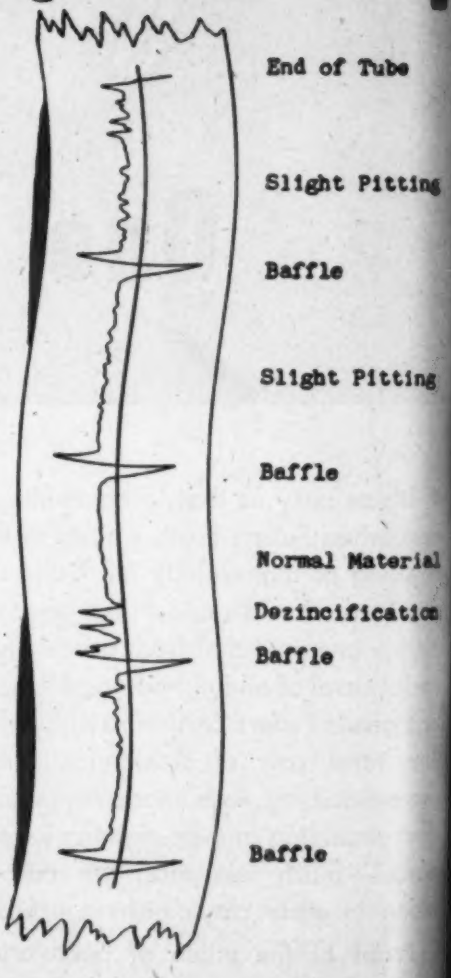
By using the device, it is possible not only to locate *quickly and accurately,* faulty, inaccessible tubes in heat exchangers, condensers and similar tubular equipment, but to obtain a graphic record of the defects as well.

How the Probolog works: A probe is pushed or pulled through a tube by a cable. As it moves through the tube, the recorder charts or flashes the position of each defect in the tube.

The Probolog detects dezincification, eroded and corroded pits, cracks, strained areas, increases or decreases in wall thickness, changes in alloy or chemical composition and abnormal changes in physical dimensions —a complete record in black and white.

The Probolog saves time and material. Dismantling and reassembling equipment is eliminated. Only defective tubes need be removed, and these may be reclaimed and salvaged.

Write for further particulars.

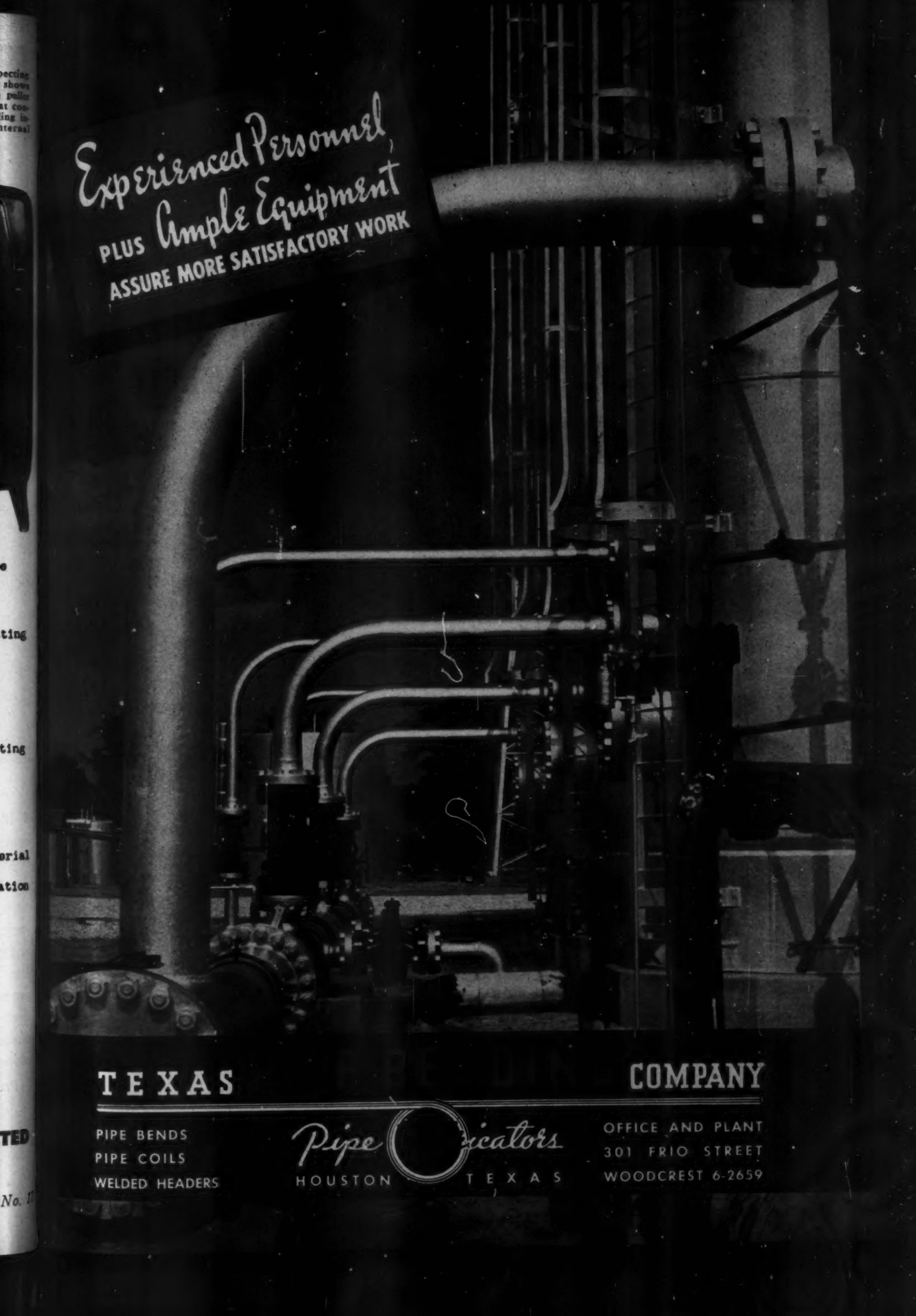


Actual graph of defective isobutane condenser tube.

SHELL

SHELL DEVELOPMENT COMPANY, INCORPORATED

50 West 50th Street, New York 20, N. Y.



TEXAS COMPANY

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PIPE COILS
WELDED HEADERS

Pipe Fabricators
HOUSTON TEXAS

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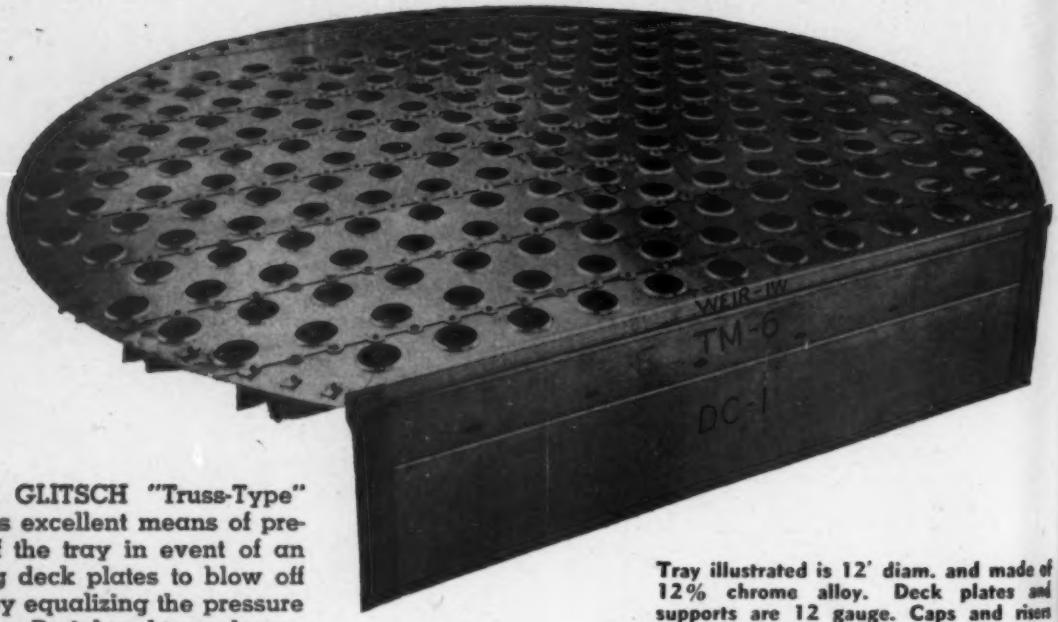
WOODCREST 6-2659

EXPLOSION

CUT DOWN EXPLOSION LOSSES BY USING *Glitsch* LIGHT WEIGHT "TRUSS-TYPE" BUBBLE TRAYS AND CAPS

Manufactured under U. S. Patents No. 2,210,808; No. 2,309,309; No. 2,338,928 and No. 2,341,091 and other Patents Pending.



Tray illustrated is 12' diam. and made of 12% chrome alloy. Deck plates and supports are 12 gauge. Caps and risers are removable with risers pulling up through the deck.

Ingenious design of GLITSCH "Truss-Type" Bubble Trays provides excellent means of preventing destruction of the tray in event of an explosion by allowing deck plates to blow off of the supports, thereby equalizing the pressure on both sides of the tray. Peripheral tray clamps hold deck plates to tower ring. Frictional washers secure plates to supporting members. These exclusive features hold explosions to a minimum loss. All parts are easily reclaimed, and it is not necessary to carry a reserve stock because GLITSCH light weight trays and caps can be straightened and reinstalled in a minmum of time.

It's a fact that "off stream" time caused by an explosion can be cut so much by the use of GLITSCH fabricated, light weight "Truss-Type" bubble trays and bubble caps that the entire cost of the trays and caps may be offset by the lessened "off-stream" time.

Manufactured under U. S. Patent No. 2,210,808; No. 2,309,309; No. 2,338,926; No. 2,341,091 and other Patents Pending

Glitsch

Fritz W. Glitsch & Sons — *Dallas 1, Texas*

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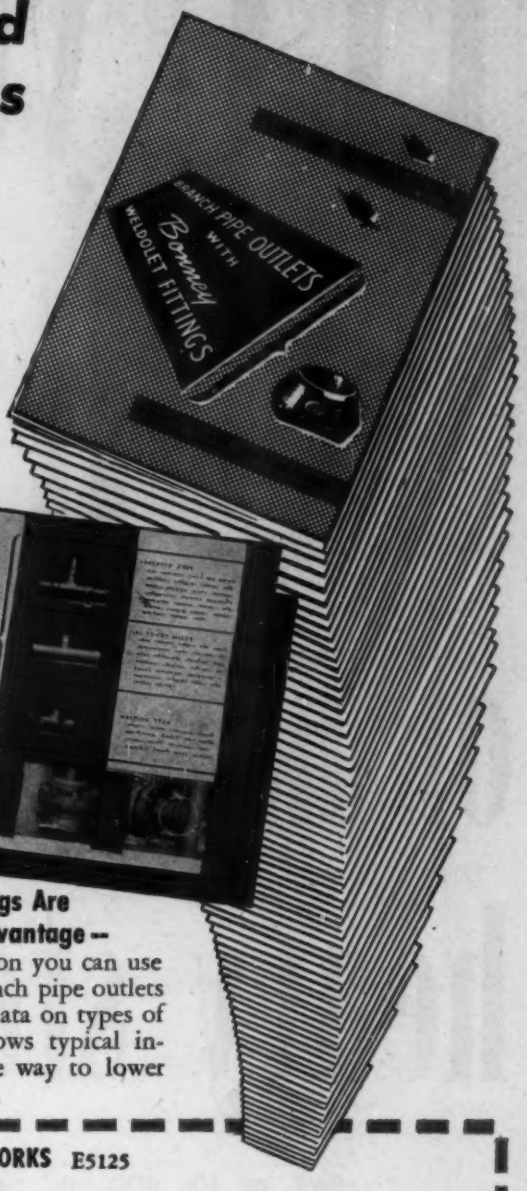
"TRUSS-TYPE" BUBBLE TRAYS • CAPS • TOWER INTERNALS

FOR BRANCH PIPE OUTLETS

That are Leak-proof and Improve Flow Conditions

PUT THIS INFORMATION TO WORK—This new catalog gives you all the information you need to get low cost branch pipe outlets. It shows how you can get stronger branch pipe outlets with WeldOlet Fittings. For your free copy of the new WeldOlet Fittings Catalog, just drop us a line.



Why These Fittings Give You Improved Flow Conditions --

The cut-away drawings on these pages show how WeldOlet Fittings reduce turbulence and friction . . . why these fittings permit full flow capacity from the run to branch pipes.

How These Fittings Are Used To Best Advantage --

Here is definite information you can use to get stronger, neater branch pipe outlets at less cost. Along with data on types of WeldOlet Fittings, it shows typical installations that point the way to lower costs on *your* piping jobs.

For
LOWER COST, STRONGER
BRANCH PIPE OUTLETS
... Ask for this catalog. It contains complete details on types of fittings available, sizes, prices, etc. This coupon or a note on your company letterhead will start the Weld-Olet Fittings Catalog on its way to your desk.

BONNEY FORGE & TOOL WORKS E5125
FORGED FITTINGS DIVISION
ALLENTOWN, PA.

Gentlemen: Please send me the latest WeldOlet Fittings Catalog.

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WELDOLETS

TRADE MARK REG. U. S. PAT. OFF. PAT. IN U. S. & FOREIGN COUNTRIES

WELDING OUTLET - THREADED OUTLET - SOCKET OUTLET

For Welded Branch Pipe Outlets

TCC yields 56% of motor gasoline from heavy stock

TCC can process stocks of any boiling range; they need not be vaporizable. In pilot plant operation, TCC has produced 56% of 10# 400 end point RVP motor gasoline in a once-through operation, from stocks having mid points of greater than 1000° F. This ability of the TCC Process to handle heaviest charging stocks becomes even more important now that automobile rather than aviation fuel is in principal demand. With TCC, you get optimum yields of high quality motor gasoline, with minimum coke—plus additional substantial volumes of readily salable heating oil. Interested refiners can submit samples of heavy stocks to Houdry Laboratories for pilot plant evaluation.

HOUDRY PROCESS CORPORATION
WILMINGTON, DELAWARE

NEW YORK OFFICE: 115 BROADWAY, NEW YORK 6

HOUDRY CATALYTIC PROCESSES

Houdry Catalytic Processes and the TCC Process are available through the following authorized firms:

E. B. BADGER & SONS CO.
Boston, Massachusetts

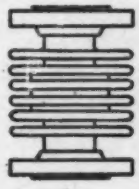
THE LUMMUS COMPANY
New York City, New York

BECHTEL-McCONE CORP.
Los Angeles, Calif.

"Clinch-lock" solves expansion joint problems for excessively high pressures . . .

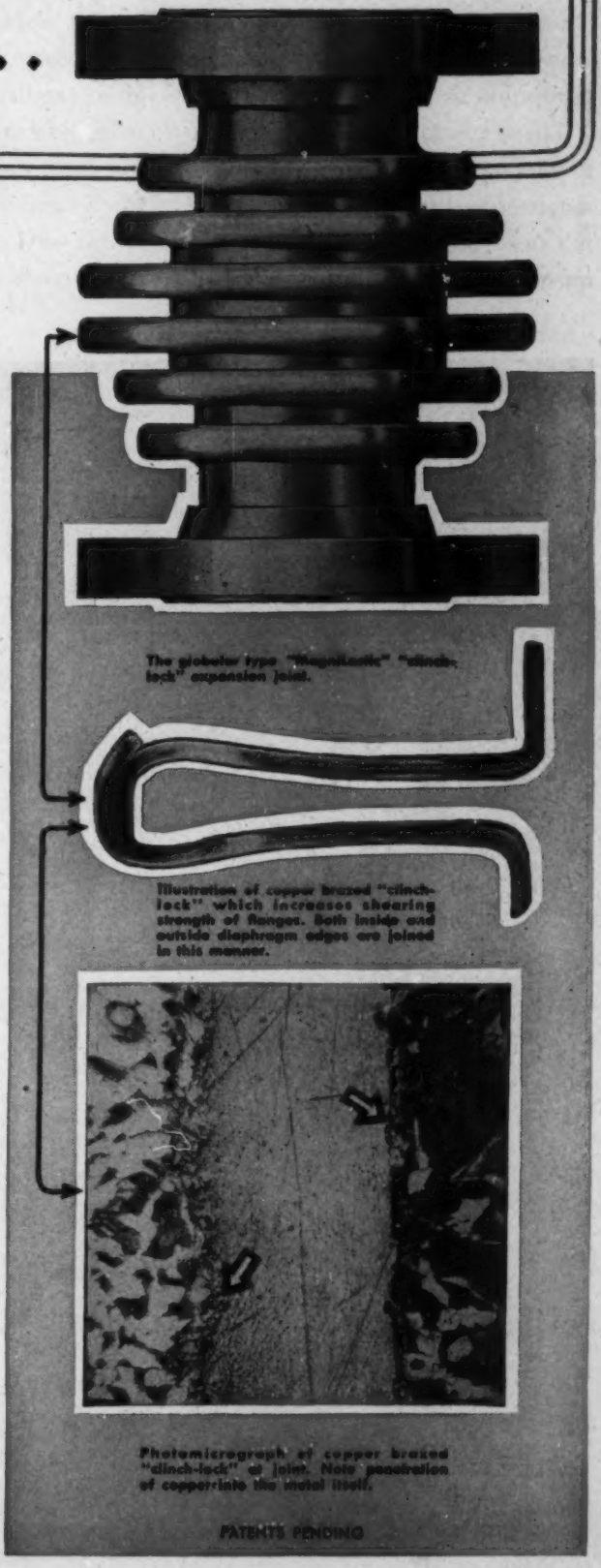
THE newest member of the Cook line of "MagniLastic" expansion joints is the "clinch-lock" type, designed especially to meet requirements where excessively high pressures must be accommodated. An example of this type of expansion joint construction is illustrated at the right. This bellows is made of a high tensile Zirconium alloy steel. The copper brazed "clinch-lock" joint, also illustrated, increases the shearing strength at the joint over the shearing tensile strength of the actual metal itself. The metal has a tensile strength of 152,000 p.s.i., — but when "clinch-locked" and copper brazed in atmosphere controlled, electric furnaces, a tensile strength of 187,000 p.s.i. is developed. The complete bellows assembly is then stress relieved and heat treated.

Two designs of "clinch-lock" expansion joints are available, the globular and parallel shapes. The globular type is especially suited as an expansion and misalignment member and is designed so that the center diaphragms have a longer flexing span than the end diaphragms, enabling a greater hinging action at the center to produce angular displacement and distribute stress forces evenly through the entire bellows assembly, thereby eliminating concentration of these stresses at the ends. This construction, forming a spherical outline makes it unnecessary to use any additional spacing bars or rings and gives uniform proportional travel to each diaphragm in relation to stress forces created.



The parallel or standard type "clinch-lock" expansion joint construction, where expansion alone is accommodated, is constructed with flanges of identical diameters. Both types are manufactured for all pipe sizes, with pressure ranges from 300 lbs. p.s.i. upwards.

The "clinch-lock" type of expansion joint represents only one of a series of high pressure expansion members. Expansion joints of other materials, such as stainless steel, Monel, Inconel and all types of metals, are manufactured to meet specific problems relating to corrosion, elevated temperatures, and other factors encountered in the specific applications. Write for details.


The globular type "MagniLastic" "clinch-lock" expansion joint.
Illustration of copper brazed "clinch-lock" which increases shearing strength of flanges. Both inside and outside diaphragm edges are joined in this manner.
Photomicrograph of copper brazed "clinch-lock" at joint. Note penetration of copper into the metal itself.
PATENTS PENDING

COOK ELECTRIC Company

SINCE 1897

CHICAGO 14, ILLINOIS

HERE'S THE "STAINLESS WAY" TO LOWER MAINTENANCE COSTS

Many refinery purchasing men know why bubble caps made of ARMCO Stainless Steels are the practical answer to excessive maintenance and production tie-ups.

These rustless steels solve both problems. They resist corrosion and require fewer inspections. The result is a steady flow of crude without frequent shut-downs for repairs. When cleaning is necessary, deposits are removed faster and more easily from the smooth surface of ARMCO Stainless.

For many years stainless caps have given excellent service in conditions ranging from mild to corrosive. Even for sweet crude, refinery men often specify stainless so they can be sure of longer service if a change is made to a sour crude.

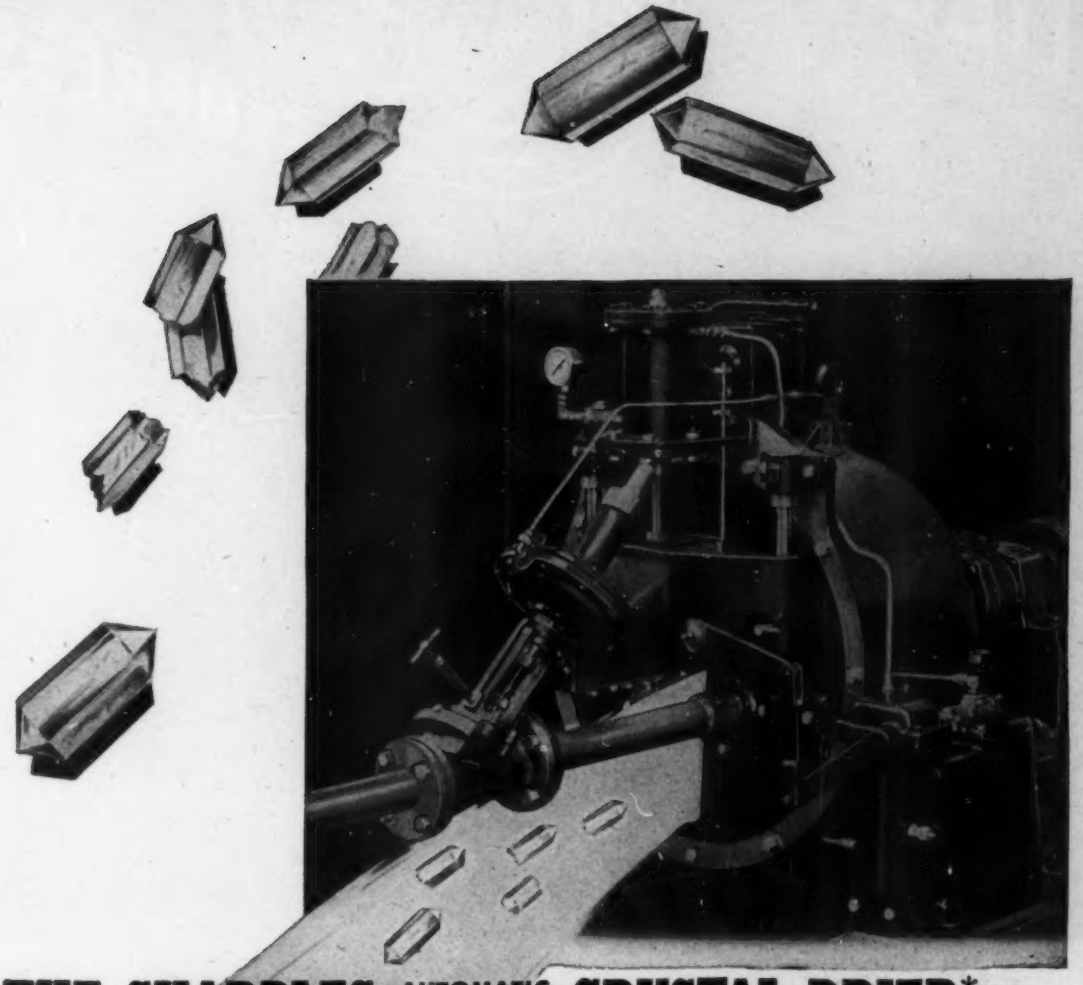
When you plan your next tower or replacement job, specify bubble caps made of ARMCO Stainless Steels. There is a grade for every requirement. For more information about the uses of these durable steels in refinery equipment, address The American Rolling Mill Company, 1841 Curtis Street, Middletown, Ohio.

EXPORT: THE ARMCO INTERNATIONAL CORP.

STAINLESS ARMCO STEEL

THE AMERICAN ROLLING MILL COMPANY

Special-Purpose Sheet Steels



THE SHARPLES AUTOMATIC Centrifugal CRYSTAL DRIER*

THE SUPER-D-HYDRATOR*

Nearly 6,000,000 pounds of crystals are being dried every day in Sharples Super-D-Hydrators. Although new in design, already this machine is handling a wide variety of crystalline materials.

The Sharples Super-D-Hydrator* is FULLY AUTOMATIC in its operation. Crystals are removed from mother liquor—efficiently washed—spun to near-dryness and discharged without attendant labor. Completely labor-free and trouble-free, THE SUPER-D-HYDRATOR provides a modern answer for the continuous automatic crystal drying problem.

If your material is crystalline, chances are that it can be handled in The Sharples Automatic Centrifugal Crystal Drier.

*Trade Name Registered

The SHARPLES Corporation

CENTRIFUGAL AND PROCESS ENGINEERS

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REPRESENTATIVES THROUGHOUT THE WORLD

Fuller Rotary Compressors are manufactured in single and two-stage types, for capacities to 3300 c.f.m. actual free-air delivery, 125-lb. pressure.

Illustrated in the installation above are three Fuller Rotary Two-stage Duplex Compressor units. Each unit has a capacity of 3300 c.f.m. actual free-air delivery, 125-lb. pressure. Purchasing its first Fuller in 1938, this company and its affiliated companies have since purchased and installed a total of 70 Fuller Rotaries. Machines range in size from the smaller single-stage type 40-lb. pressure to the large two-stage type shown above.

Fullers have many outstanding features which recommend them for your consideration. One very important feature—due to their unique design—original capacities are maintained for the life of the machine. Bulletin C-5 gives detailed information. We'll be glad to send you a copy.

FULLER COMPANY, CATASAUQUA, PA.

Chicago 3 - 1144 Marquette Bldg.
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C-130

FULLER

PIONEERS OF HIGH-EFFICIENCY ROTARY COMPRESSORS

CONTROL VAPOR TEMPERATURE with EXPERTLY JACKETED FLORI PIPING
Vapor is tricky stuff: if overheated it turns to steam—if it gets a chill it turns to water. To keep vapor healthy you must keep its temperature "normal".
Solution: Flori piping with hand-tailored jackets. Our expert welding workmanship assures finer fit—perfect circulation—constant temperature control.
IF IT'S FABRICATION—CONTACT FLORI
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OUR PRE-WAR REPUTATION:
OUR WAR RECORD:
OUR POST-WAR PLAN:

QUALITY AT LOWEST DOLLAR COST

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BARGES, TUGS
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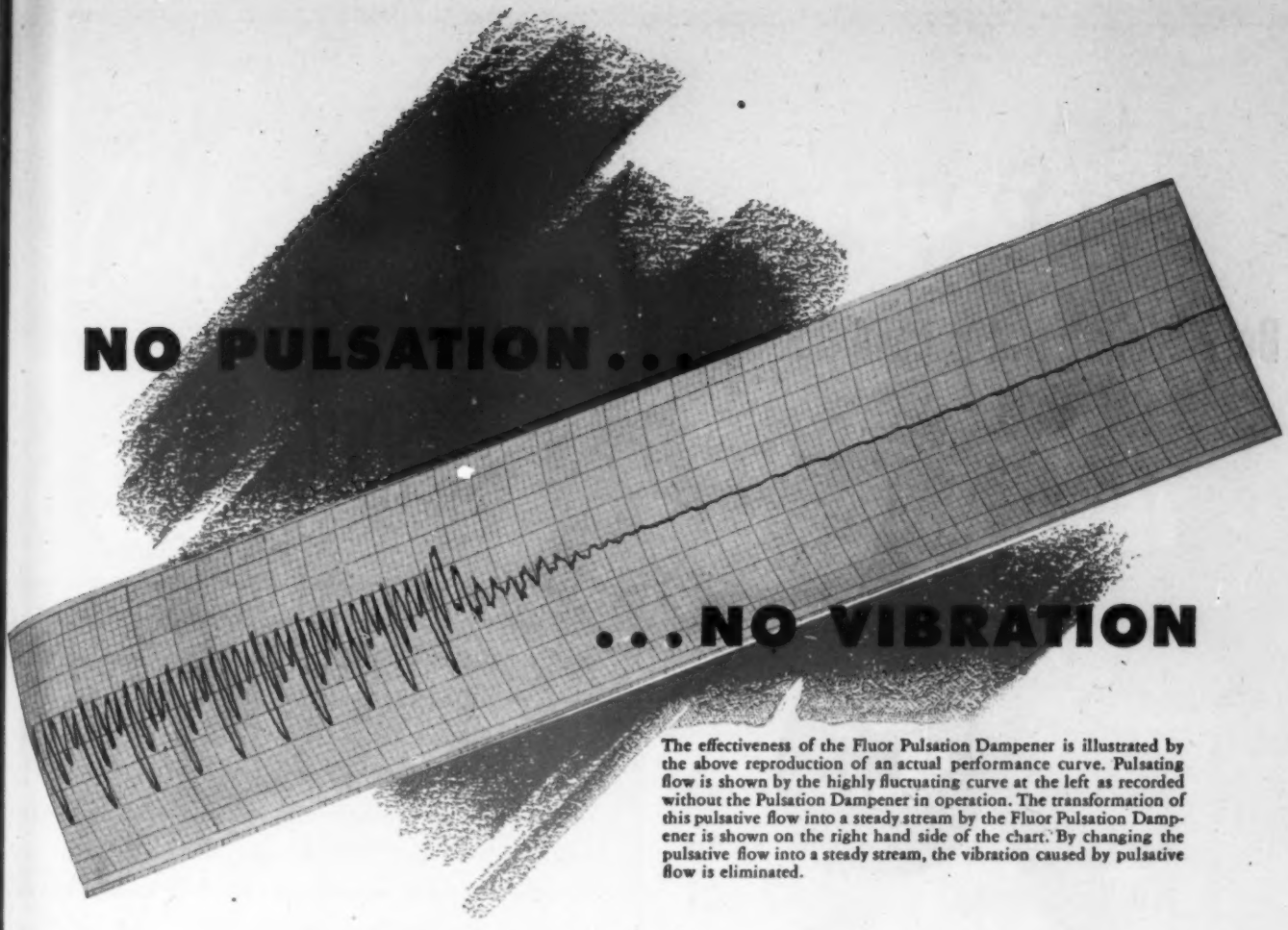
STEEL

AVONDALE MARINE WAYS, INC.

TELEPHONE: OFFICE AND PLANT, WALNUT 8970

RIVER FRONT, NEW ORLEANS DISTRICT, WESTWEGO, LOUISIANA



The effectiveness of the Fluor Pulsation Dampener is illustrated by the above reproduction of an actual performance curve. Pulsating flow is shown by the highly fluctuating curve at the left as recorded without the Pulsation Dampener in operation. The transformation of this pulsative flow into a steady stream by the Fluor Pulsation Dampener is shown on the right hand side of the chart. By changing the pulsative flow into a steady stream, the vibration caused by pulsative flow is eliminated.

THE FLUOR PULSATION DAMPENER smooths pulsative flow into a steady stream in pipe lines carrying air, vapors or gases . . . regardless of engine speed, pressure or rate of flow. Designed for the *lowest* operating speed, it works even more efficiently as speeds are *increased*. No adjustments are necessary for higher frequencies. Constant maintenance necessary with mechanical dampeners is eliminated. Danger of line breakage from vibration is removed.

You can save on labor, materials and maintenance by specifying the FLUOR Pulsation Dampener on all new installations . . . and by installing it in your present lines where vibration is a constant problem and expense. Write for descriptive bulletin.

The FLUOR Pulsation Dampener is part of the piping system . . . not just a fixture. *Patents pending.*

BE SURE WITH FLUOR SINCE 1890

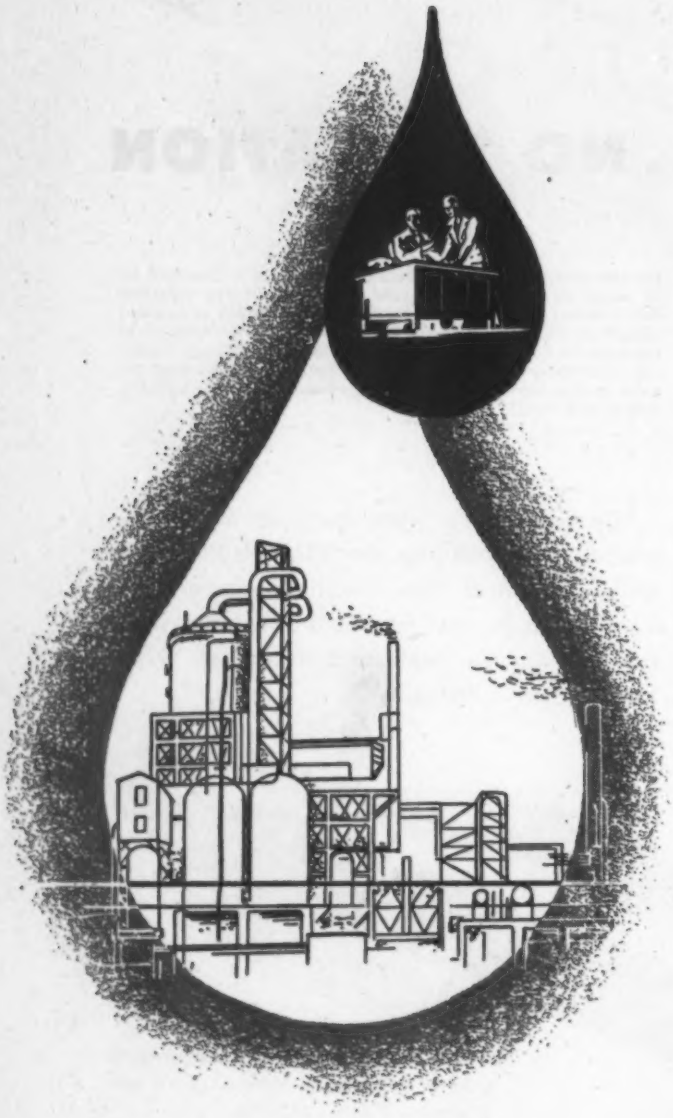
FLUOR

ENGINEERS • MANUFACTURERS • CONSTRUCTORS

PROCESS PLANTS AND EQUIPMENT FOR THE OIL, GAS AND ALLIED INDUSTRIES

THE FLUOR CORPORATION, LTD., 2500 S. Atlantic Blvd., LOS ANGELES 22 • New York, Pittsburgh, Kansas City, Houston, Tulsa, Boston

Betz cooling water conditioning is a SPECIALIZED SERVICE



● It has often been said that we live in an age of specialization and this fact is perhaps nowhere better recognized than in the petroleum industry. Maximum plant operating efficiency and the development of new or vastly improved products resulted largely from the work of specialists in many lines.

And so it is in the study and control of cooling water systems. Here the work of specialists—chemists and chemical engineers who devote all their knowledge and talents to the problems of industrial water conditioning—assumes major importance. W. H. & L. D. BETZ is an organization of such water specialists qualified by long experience to correctly diagnose all types of cooling water problems—particularly those encountered in the petroleum field. It is an organization equipped with all facilities to give you a complete service—from plant design on new cooling water systems to recommendations leading to improved operations of systems already "on line".

If the results you are presently obtaining are not completely satisfactory we would appreciate the opportunity of a preliminary discussion to more fully explain how our specialized service can be of benefit to you.

W. H. & L. D. BETZ, Gillingham and Worth Streets, Philadelphia 24, Pa.

COOLING WATER CONDITIONING • BOILER WATER CONDITIONING

INDUSTRIAL WASTE DISPOSAL

BETZ

Call THE CORBETT CORPORATION *for*

GLOBE STEEL TUBES for seamless steel boiler and condenser tubes.

Among the well known lines available to you through The CORBETT CORPORATION are:—

TAYLOR forged Steel Flanges and Fittings • JENKINS Valves • YOUNGSTOWN Pipe • ROCKWOOD Unions • WATSON-STILLMAN Forged Steel Fittings • GLOBE Boiler and Condenser Tubes • LAMSON & SESSIONS Rivets and Bolts • WORTH Steel Heads and Plates.

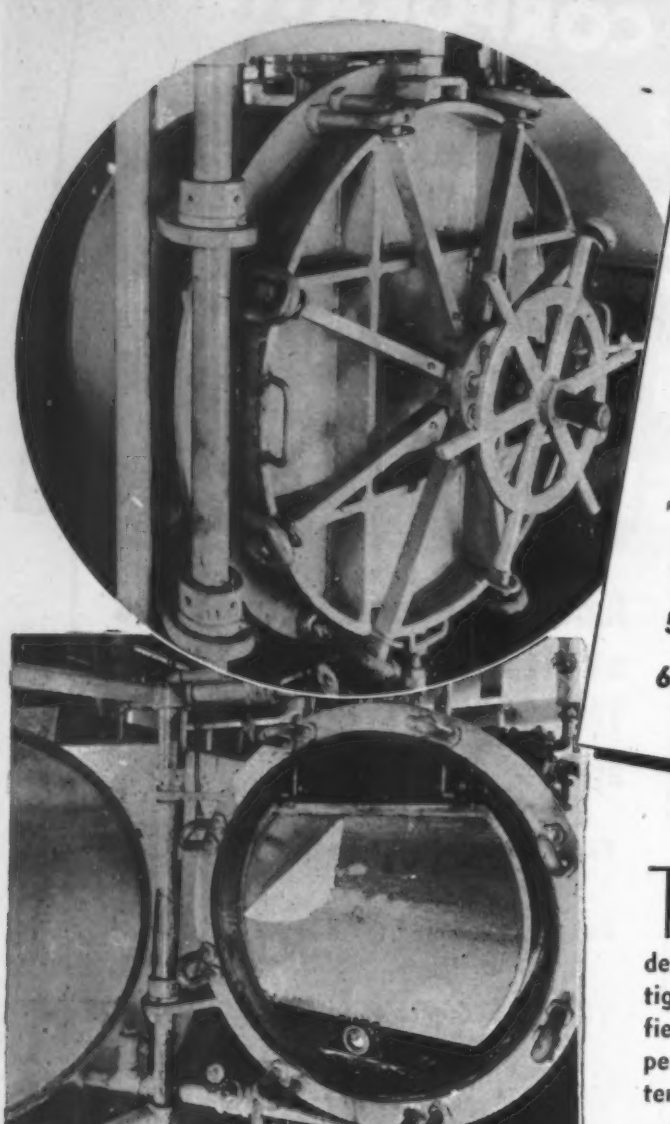
Available in Houston Stocks

The **CORBETT** *Corporation*

CAPITOL 5325

2431 SUMMER ST. P. O. BOX 42 HOUSTON 1, TEXAS

Removes ALL OIL from condensed returns used for boiler feed



Upper picture shows the Refiner with special quick-locking door in place. Lower photo shows door open. Note how filter bed is peeled easily from pressure leaves in one piece.

The REFINER

A revolutionary new filter PROVEN IN SERVICE

1. Eliminates oil entering boilers. Improves boiler efficiency. Reduces boiler maintenance costs.
2. Saves heat units and fresh water by clarifying contaminated returns formerly dumped.
3. Removes free and EMULSIFIED oil from water to less than one-tenth part per million.
4. Requires no chemicals or wasteful back-washing.
5. Is simple, inexpensive to operate.
6. Requires little space.

THE REFINER is an outstanding achievement in filters designed for extremely fine filtration. It breaks the tightest emulsion in condensate and removes both emulsified and free oil from an oil content as high as 90 parts per million down to a guaranteed maximum of one-tenth ppm.

The REFINER features compactness and low-cost operation. Flow rates of 20 to 200 gpm are obtained in single units. A battery of units provides greater capacities. The cost of filtered liquid by this new method of emulsion breaking is extremely low. No back-wash water is used.

The REFINER will greatly step up the efficiency of your plant and reduce boiler maintenance costs. Engineering assistance will be furnished gladly.

WRITE FOR CATALOG

APPLICATIONS

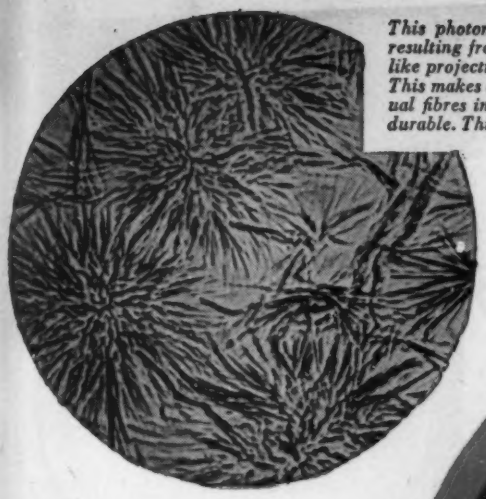
The REFINER can be used as a polishing filter for practically any liquid, including boiler feed water and condensate, alcoholic, malt and other beverages, chemicals, aromatics, paints, varnishes, lacquers, soaps, detergents, juices and liquid foods, and liquids used in processing other substances. The pressure-tight cylinder permits filtration of volatile, inflammable, and hazardous liquids. It also removes turbid matter of the same specific gravity as the liquid.

BLACKBURN-SMITH
MANUFACTURING COMPANY, INC.

For 60 years designers and manufacturers of filters

74 River Street, Hoboken, N. J.

Blackburn-Smith Mfg. Co. is a wholly owned subsidiary of Condenser Service & Engineering Co., Inc., builders of Evaporators, Steam Heaters, Gas Coolers, Drain Coolers and Heaters, Aftercoolers, Air Preheaters, Fuel Oil Heaters, Jacket water Coolers, Process Heat Exchangers, Transformer Oil Coolers, Generator Air Coolers, Lubricating Oil Coolers, Storage Tank Oil Heaters, Feed Water Heaters, Distillers, Industrial and Oil Refinery Heat Exchangers, and other types of heat exchange equipment.



This photomicrograph shows the distinctive lead "soap" formations resulting from Red Lead's reaction with the vehicle. Note how the rod-like projections radiating from central cores spread out and intermesh. This makes a strong, flexible, interwoven structure—just as the individual fibres in a piece of cloth are intertwined to make cloth tough and durable. This type of soap formation is unique with "lead" paint films.

unique LEAD SOAPS...

another important reason why RED LEAD means Extra Rust Protection

Why is Red Lead outstanding as a metal protector?

One of the major reasons is this pigment's remarkable ability to impart to the paint film strong, tough, intertwining lead "soap" formations—as shown in the photomicrograph above.

These unique lead "soaps" improve the paint film in many ways. For one thing, they form a dense, intermeshing matrix which restricts the passage of water through the film. And rusting does not take place without the presence of moisture.

For another, they *mechanically* reinforce the film, giving it extra *strength* and *toughness*.

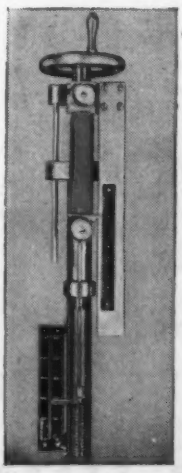
And again, Red Lead "soaps" contribute all-important *elasticity* — allowing movement along their intermeshing projections. This action helps prevent the ruptures to which a hard, unyielding film is subject. Moreover, when a paint film dries and ages, decomposition of the vehicle sets in. But, because of Red Lead's ability to combine with the decomposition products and form soaps, it increases both the durability of the paint film and its adhesion to the base metal.

Red Lead's extra strength, toughness and elasticity are demonstrated by the tensile strength test below and substantiated by exhaustive research and field service.

Remember, too, that Red Lead is compatible with practically all vehicles commonly used in metal protective paints, including phenolic and alkyd resin types.

Specify RED LEAD for All Metal Protective Paints

The value of Red Lead as a rust preventive is most fully realized in a paint where it is the only pigment used. However, its rust-resistant properties are so pronounced that it also improves any multiple pigment paint.



* * *

In this tensile strength tester a typical Red Lead paint film has been stretched 18% without breaking. In withstanding this elongation it has maintained a load of 920 grams. Any film that exhibits these characteristics has unusual strength, toughness and elasticity. As metals expand and contract only a fraction of one percent, this film would adhere under the most extreme conditions.

No matter what price you pay, you'll get a better paint for surface protection of metal, if it contains Red Lead.

Write for New Booklet—"Red Lead in Corrosion Resistant Paints" is an up-to-date, authoritative guide for those responsible for specifying and formulating paint for structural iron and steel. It describes in detail the scientific reasons why Red Lead gives superior protection. It also includes typical specification formulas—ranging from Red Lead-Linseed Oil paints to Red Lead-Mixed Pigment-Varnish types. If you haven't received your copy, address nearest branch listed below.

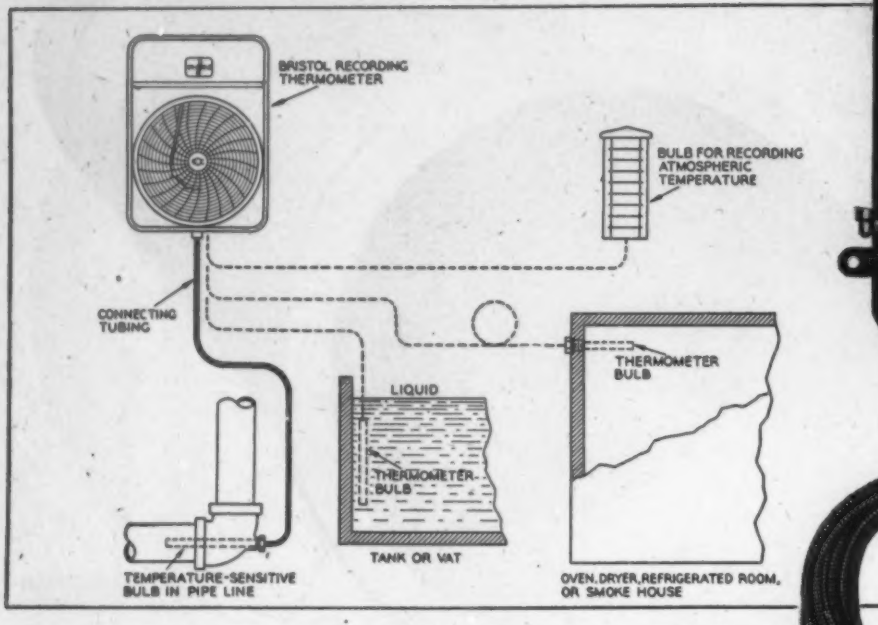
* * *

All types of metal protective paints are constantly being tested at National Lead's many proving grounds. The benefit of our extensive experience with Red Lead paints for both underwater and atmospheric use is available through our technical staff.

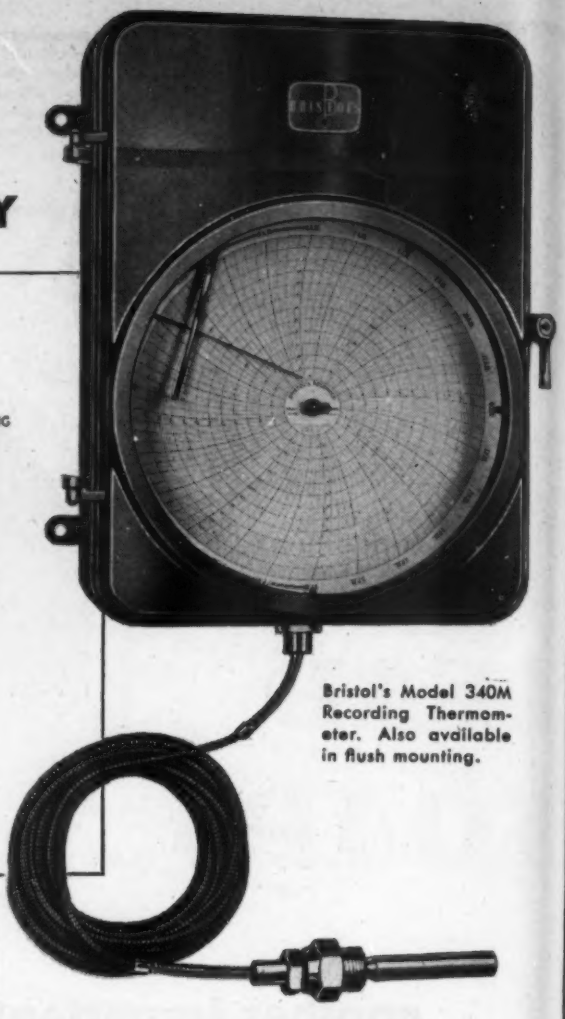
NATIONAL LEAD COMPANY: New York 6, Buffalo 3, Chicago 80, Cincinnati 3, Cleveland 13, St. Louis 1, San Francisco 10, Boston 6 (National-Boston Lead Co.); Pittsburgh 30 (National Lead & Oil Co. of Penna); Philadelphia 7 (John T. Lewis & Bros. Co.); Charleston, W. Va. (Evans Lead Division).

DUTCH BOY RED LEAD

HOW TO ATTAIN HUMANLY-IMPOSSIBLE HEAT CONTROL and ECONOMY



Typical applications of Bristol's Model 340M Recording Thermometer for wall mounting, with ranges from −125°F. to +1000°F. or Centigrade equivalent.

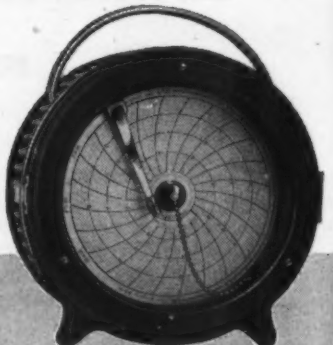


Bristol's Model 340M Recording Thermometer. Also available in flush mounting.

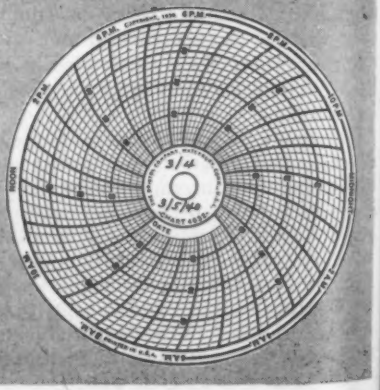
Recording Thermometers stationed at strategic points give management a permanent record of all significant variations of temperature, even momentary, with the time at which they occurred, for study and comparison with other data. With such records, it is easy to determine whether the most economical temperatures are maintained.

Side-by-side comparison of chart records will reveal points where, by supplementing the recording thermometer with completely automatic control, important temperatures can be accurately maintained at intended values. This combination assures the utmost in economy by eliminating problems common to manual control and gives results that are often humanly impossible to attain.

The Bristol Company manufactured the first bulb-and-tubing type recording thermometer 52 years ago. Continuous development and improvements make Bristol Thermometers the most modern in the field of temperature measurement. Write for full details about Bristol Recording Thermometers and Automatic Temperature Control. The Bristol Company, 111 Bristol Road, Waterbury 91, Conn.



Bristol's Portable Recording Thermometer produces 24 hr. continuous records on 4-inch charts.



BRISTOL

Engineers process control for better products and profits

DO YOU KNOW WHAT LITHOWAXES ARE AND HOW MUCH THEY MEAN TO YOU?

IF YOU are not familiar with lithowaxes and their uses, you are overlooking an important war development with outstanding present and postwar possibilities.

Briefly, lithowax is a mixture of lithium stearate (Foote Litholite A) with low cost macrocrystalline paraffin waxes. The result is a wax with these advantages:

1. Increased tensile strength, 2. Lowered cold crack, 3. Lowered tack or stickiness, 4. Improved heat-sealing characteristics, 5. Reduction of crystal size of wax, 6. High dropping point, 7. Lowered cost of wax.

There are many possible mixtures or combinations of lithium stearate and paraffin wax, therefore many kinds of lithowax for many purposes, such as these:

PAPER COATINGS—Lithowaxes provide better heat sealing characteristics, do not flake or crack when cold, do not *block* with high seasonal temperatures.

FABRIC COATINGS—Lithowaxes do not dull or cloud color. Improve "feel" of fabric and effectively waterproof it.

COSMETICS—Lithowaxes replace expensive natural waxes in creams without lowering product quality.

ELECTRICAL INSULATION—Lithowaxes increase useful temperature and atmospheric ranges. Less dust-collecting "tackiness." More flexibility.

PENCILS AND CRAYONS—Lithowax wax pencils and crayons do not crack or soften under normal conditions. Marking quality improved.

PRINTING INKS AND PAINTS—Lithowax is used in containers, milled into inks for topographic and lithographic uses. Good scratch resistance. Increases water-proofing of paints. Has good flattening effect.

POLISHES—Better resistance to checking and cracking than natural waxes.

OTHERS—Sound recording waxes, candles, dental waxes, adhesives, protective coatings for metals and many more uses.

Remember, please, we do *not* manufacture lithowaxes commercially. We do make test quantities of lithowax for trial only. We do make lithium stearate. We do cooperate in developing lithowax uses.

METALS & ALLOYS--A LA CARTE

Though you may first think of us as processors of ores and chemicals, a substantial percentage of our job is supplying alloys and metals of guaranteed analyses to industry . . . powdered to our standards or granulated a la carte to your specs.

Lump of Ferro Manganese before granulation.

Foote
MINERAL COMPANY
A Step Ahead in Industrial Ores and Chemicals

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Home Office: 515 GERMANTOWN TRUST CO. BLDG., PHILA. 44, PA.
West Coast Representative: Griffin Chemical Co., San Francisco, California

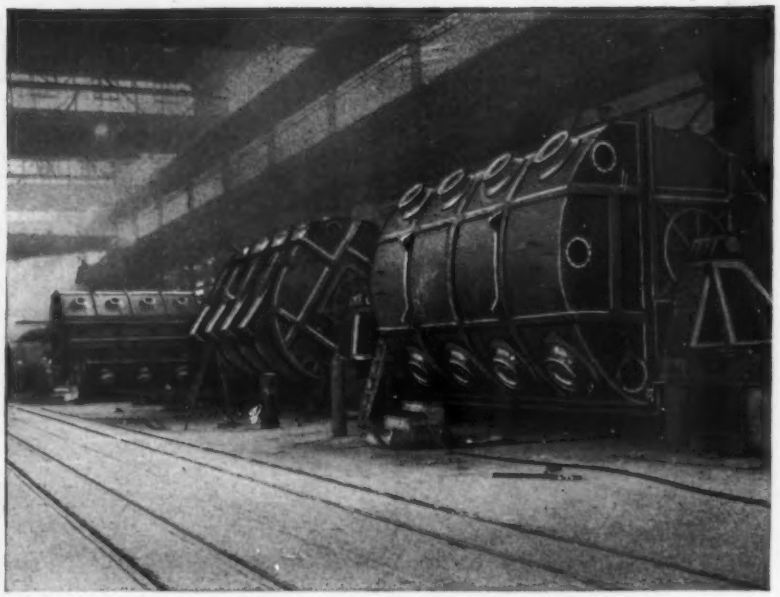
GENERAL AMERI

WE HAVE FACILITIES AND EXPERIENCE

CONKEY DEWAXING FILTERS

. . . for both dewaxing and product wax recovery are precision built in General American shops to General American standards of better built equipment for superior performance.

The Sharon, Pa. shops not only contain the most up-to-date plate and welding apparatus but specialized equipment which permits the building of large quantities of filter equipment quickly and efficiently. Shipping facilities are excellent as the Sharon plant has direct connections to the New York Central, P. & L. E., Erie and Pennsylvania railroads.



CONKEY FILTERS AND EVAPORATORS, TURBO-MIXERS, PETERSON FILTERS, GENERAL AMERICAN HYDROSEPARATORS AND CLASSIFIERS, AMERICAN DRUM DRYERS, LOUISVILLE ROTARY DRYERS, COOLERS AND PRESSES

GENERAL AMERICAN TRANS

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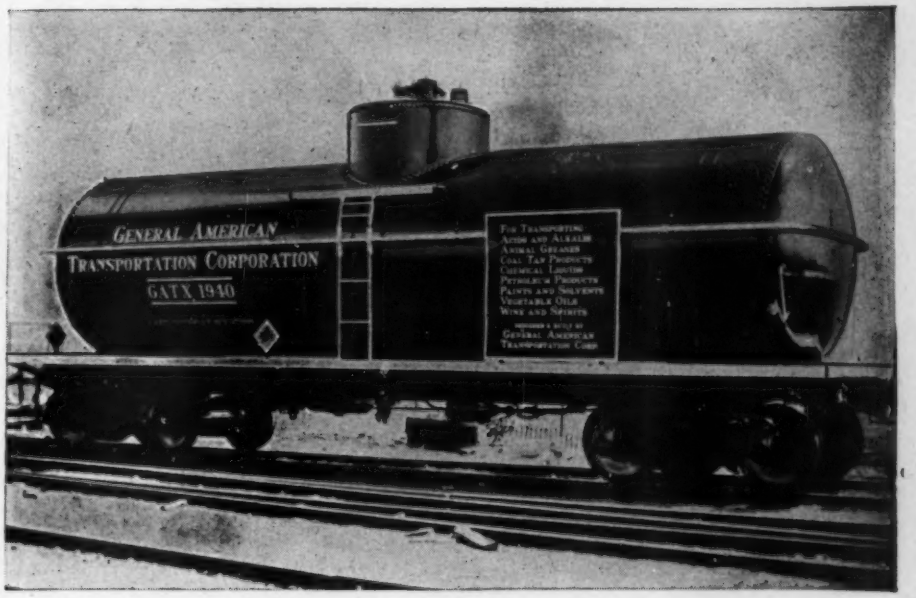
ICAN designs and builds

TO HELP SOLVE YOUR PROBLEMS

PLATE FABRICATION OF EVERY KIND

"GATX" Tank Cars — famous throughout the world — are but one of the many diversified products of steel fabrication by General American. You name it, we'll build it . . . from any carbon, stainless, or alloy steel, aluminum or other special alloy, either welded or riveted.

A completely equipped fabricating plant with facilities for X-raying, heat treating, stress relieving—consulting engineering service, chemical and physical testing laboratory, specialized organization for field erection. Write today for complete information.



TANK CARS, PRESSURE VESSELS, KILNS, HEAT EXCHANGERS, STILLS, PREHEATERS, DIGESTERS, PRODUCT TANKS, BINS, PENSTOCKS, SCRUBBERS, CRYSTALLIZERS, CREOSOTING CYLINDERS, ETC.

PORTATION CORPORATION

PLATE AND WELDING DIVISION

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Chapman

Tilting Disc Check Valves

Prevent Slam and Reduce Head Losses

Made in iron, bronze and steel. For working pressures to 3000 lbs. per sq. in.

Because of the cushioning effect of the stream against its short flap, the balanced disc closes quickly and quietly, preventing water hammer and resultant destructive stresses in pipe lines. Cuts head losses to about a quarter of those caused by ordinary types of check valves, thus permitting substantial power savings where installed on pump discharge lines. Send for Bulletin No. 30 for complete information.

Chapman Valve Manufacturing Co., Indian Orchard, Mass.

CHAPMAN NON-SLAM CUSHIONED CLOSING **CHECK VALVES**

ONE Unit
ONE Source
ONE Guarantee

Split-Case Centrifugal Pumps. Single-stage or two-stage—especially designed for high-speed handling of low viscosity liquids at a wide range of heads. Single-stage pump shown.

Only Fairbanks-Morse offers a complete line of pumping units with pump, driver, and base designed and built by one company. There's no waiting by the pump manufacturer for specifications from the driver manufacturer. There's no adjusting or adapting necessary—pump and driver (motor or engine) are perfectly aligned and tested together at the factory. There is no question of responsibility for service—a Fairbanks-Morse engineer is familiar with the whole unit. And a single guarantee covers the entire installation.

Have your pump problems solved easily and simply with just one call. Write Fairbanks, Morse & Co., Fairbanks-Morse Building, Chicago 5, Ill.

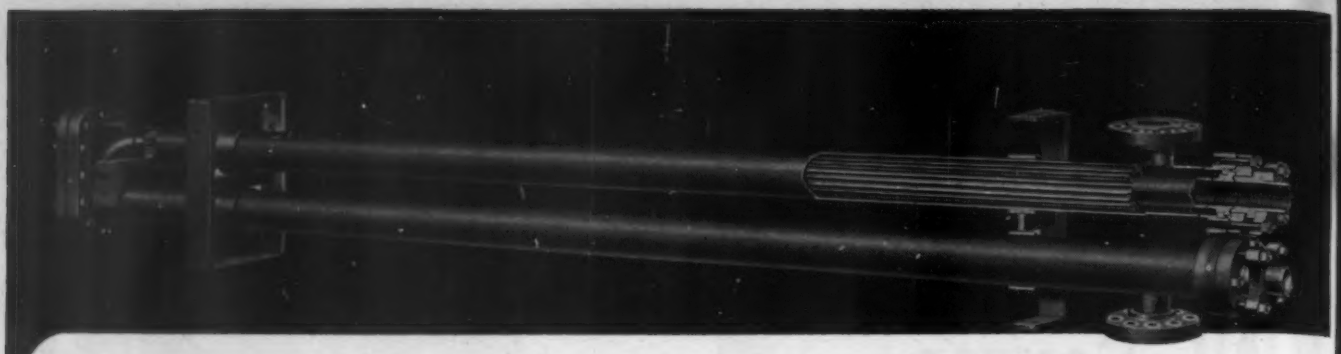
Builtogether Pumps. Efficient, compact, and sturdy. Especially designed for general pump service where floor space is limited. Single-stage or two-stage to handle ordinary or high-speed pumping against heads from 260 to 550 feet.

Buy Victory Bonds

Fairbanks-Morse

A name worth remembering

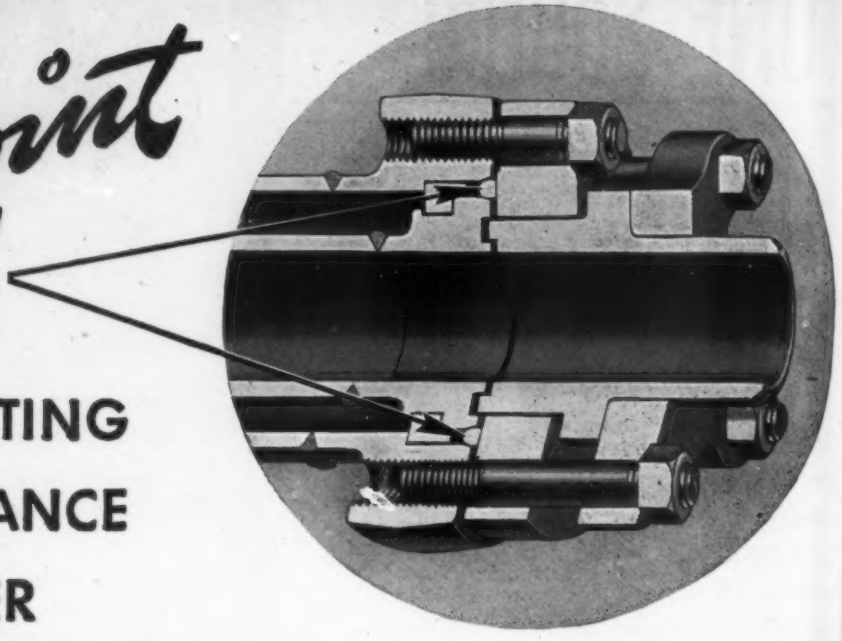
Oil Field Equipment • Diesel Locomotives • Diesel Engines • Generators • Motors • Pumps
Scales • Magnetos • Stokers • Farm Equipment • Railroad Motor Cars and Standpipes



This

Ring Joint Seal

is why OPERATING and MAINTENANCE MEN PREFER



BROWN FINTUBE *Sectional* Heat Exchangers

● Recognized by engineers everywhere as the ideal closure, this ring joint seal assembly avoids packed joints, glands, ground joint seals, screw unions, and all the operating and maintenance troubles resulting from ground joint and screw union construction.

Seating surfaces of the shell flange and fintube fitting are in full view and easily accessible. They can be wiped clean of all grit and dirt before closing the seal,– not possible with inside ground joint construction. The soft metal ring overcomes any slight unevenness of the seating surfaces,–permits tight, leak-proof closures to be made time after time,– and assures trouble-free operation far surpassing that offered by other types of closures.

Enthusiastically endorsed by operating and maintenance departments of oil refineries and chemical processing plants, the ring joint seal is but one of the many exclusive features only Brown Fintube Sectional Heat Exchangers can give you. Brown's exclusive "one-piece" fintubes whose high heat transfer efficiency is maintained undiminished during the entire life of the tube, –our exclusive non-removable rear end construction, and replaceable stud bolting throughout, are some of the others.

But send today for our fully descriptive catalog, and let Brown Fintube engineers, with their long experience in this work, help you in adapting Brown Fintube Sectional Heat Exchangers to your exact and individual requirements.

THE BROWN FINTUBE COMPANY

121 HURON STREET • ELYRIA, OHIO

Send for Bulletin No. 452

MANUFACTURERS OF BROWN RESISTANCE-WELDED INTEGRALLY BONDED ONE-PIECE FINTUBES, AND FINTUBE HEAT TRANSFER PRODUCTS

TIME TO TAKE CENSUS OF CRITICAL PRESSURE POINTS

Giving them fully automatic control often tunes up an entire operation

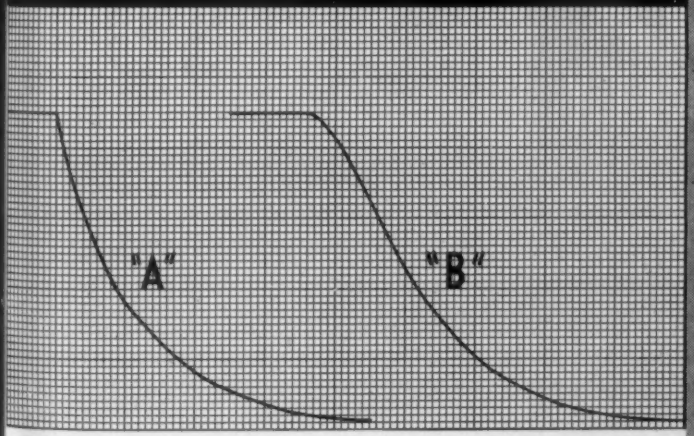
Satisfactory control at pressure stations is often taken for granted. Yet a moment's thought will reveal that many of those stations are potentional trouble spots . . . sometimes leading to serious irregularities in a critical process. Why not check up now, before you swing into full peacetime production?

Chances are, all you need to eliminate any such trouble spot is a Stabilog Pressure Controller of the standard proportional-with-reset type. Unlike temperature, there's seldom a serious problem of lag in pressure or flow control . . . seldom the need for an instrument having special rate-sensing action.

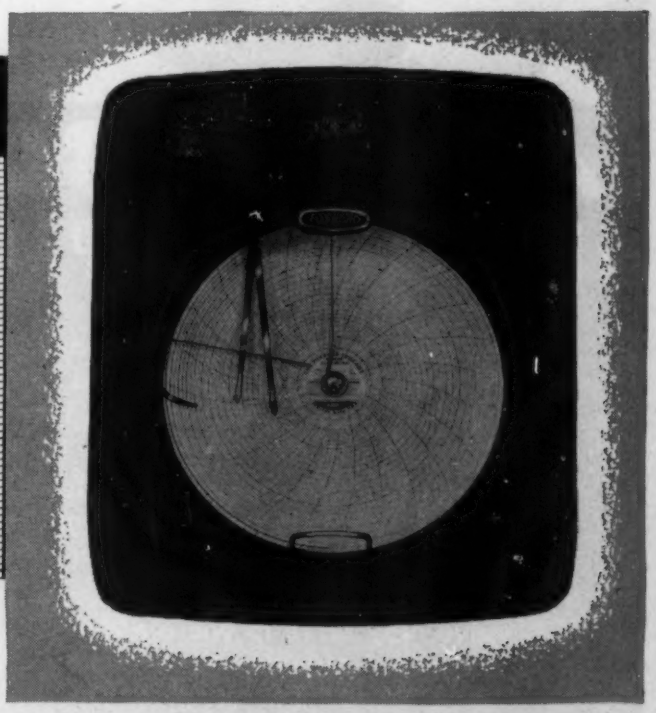
Stabilog Pressure Controllers are designed throughout for fidelity of measurement and control. Pressure springs are engineered to be uniformly accurate and fatigue-free. Mechanisms with exclusive Foxboro refinements eliminate dead space and friction. And Foxboro's Stabilog Controllers – the first to use proportional-with-automatic-reset action – have never been surpassed in performance.

Write for detailed specifications on Stabilog Controllers for any pressure up to 10,000 psi. The Foxboro Company, 74 Neponset Avenue, Foxboro, Mass., U.S.A. Also Montreal, Canada. Branches in principal cities.

HOW TO CHOOSE PRESSURE CONTROLLERS

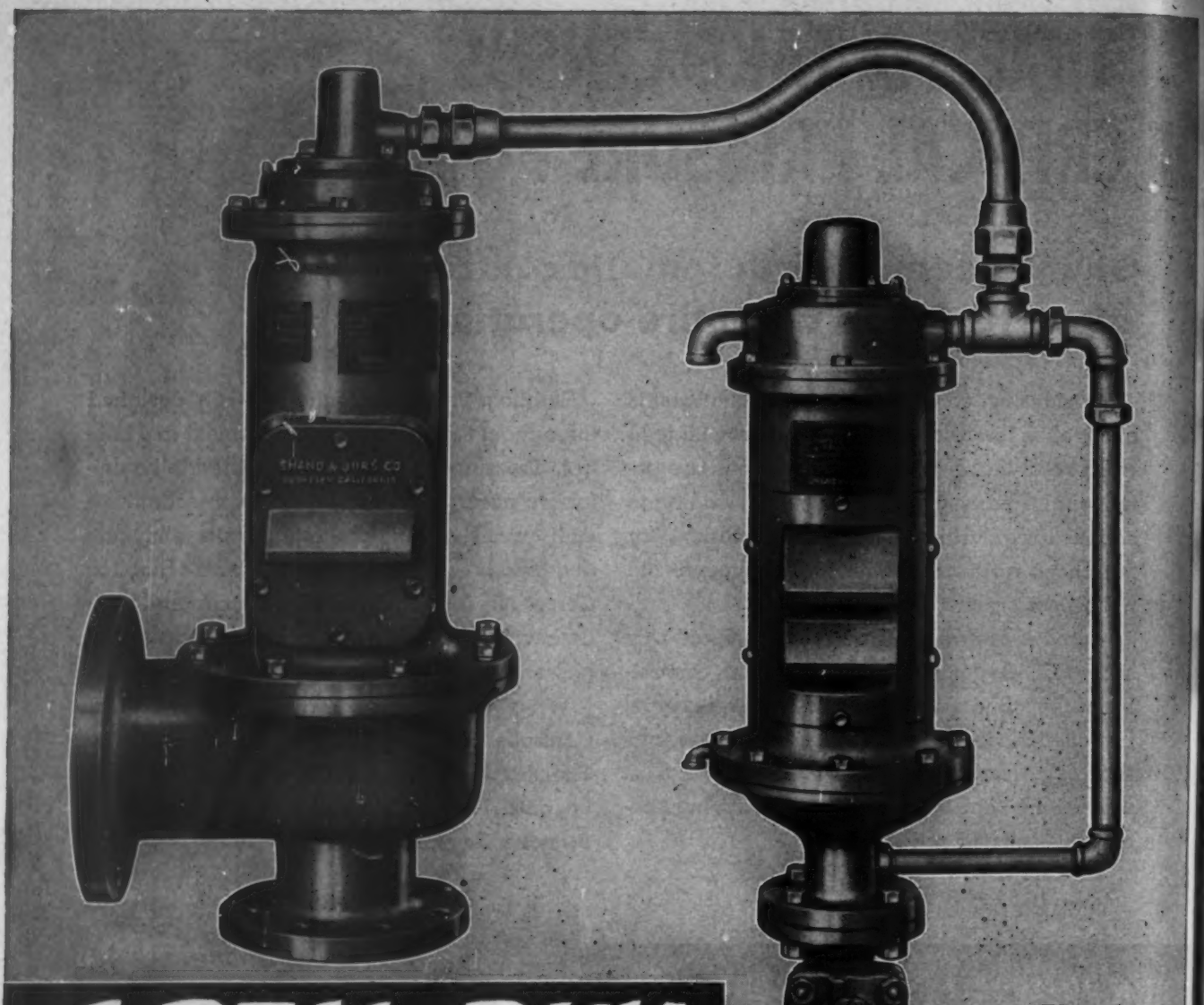


If the record of a pressure change under hand operation is similar to Curve "A" above, direct control by a Stabilog Proportional-with-Reset Pressure Controller is the simple, sure prescription. (Rarely does pressure or flow control involve a process lag as revealed by Curve "B"; such conditions generally require HYPER-RESET Stabilog Control.)



FOXBORO
REG. U. S. PAT. OFF.

AUTOMATIC PRESSURE CONTROLLERS



A REAL BUY IN VENTING CAPACITY

S&J

The astute buyer of petroleum tank venting equipment is primarily interested in three factors: SAFETY, CAPACITY, and PRICE. No other pressure regulator on the market gives the buyer so much for his money as the S. & J. Fig. ST-2500 Regulator shown above.

Design features compound the Tank Working Pressure for use in breaking ice, coke, or gummy substances which might form on seats or parts. The design also provides for the safety of the tank under other unusual conditions.

The S. & J. Regulator consists of two units—a Main Valve and a pilot valve. One pilot valve may serve to operate a number of Main Vent Valves. Dollar for dollar, this arrangement provides more venting CAPACITY than any other arrangement offered to date. Write for complete details and prices.

SHAND & JURS CO. BERKELEY, CALIFORNIA • New York · Chicago · Houston · Los Angeles · Seattle

SHAND & JURS

EFCO

HEAT EXCHANGERS
deliver Top Performance because:

1. **EFCO ENGINEERS ARE HEAT EXCHANGE SPECIALISTS WITH YEARS OF EXPERIENCE** . . . Result: thoroughly designed and engineered heat exchangers that side-step trouble, save money, and operate at high efficiency.

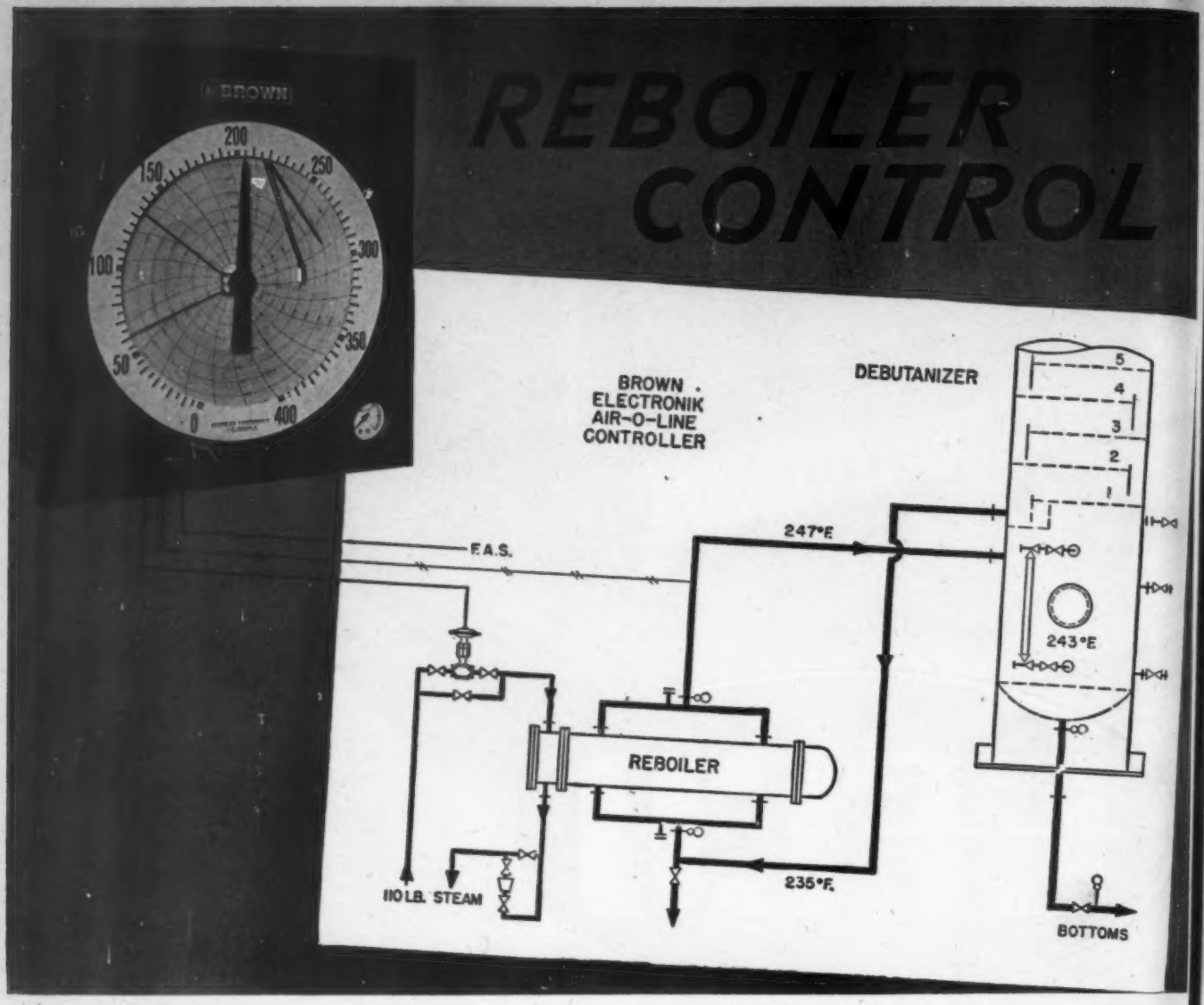
2. **SUPERIOR WORKMANSHIP** by men who specialize on heat exchangers assures extra durability, lower maintenance cost, and long service.

EFCO regularly designs and fabricates heat transfer equipment for the nation's leading companies.

ENGINEERS & FABRICATORS, INC.

P. O. BOX 7395 — EFCO — HOUSTON, TEXAS

REBOILER CONTROL



Controlled heat input is a major factor in maintaining maximum operating efficiency of continuous fractional-distillation columns. In one modern petroleum refinery, the heat input to a debutanizer tower is supplied by a thermosyphon reboiler, as shown in the diagram. Feed to the reboiler is taken from the bottom tray at 235° F. and heated to 247° F. for return.

Constant control of heat input is maintained by the Brown ElectroniK Potentiometer — Air-o-Line Controller. The temperature of the feed is continuously measured and the rate of steam flow to the reboiler is controlled. The controlled rate of heat input permits the 30-tray tower to operate continuously at a bottom temperature of 243° F.

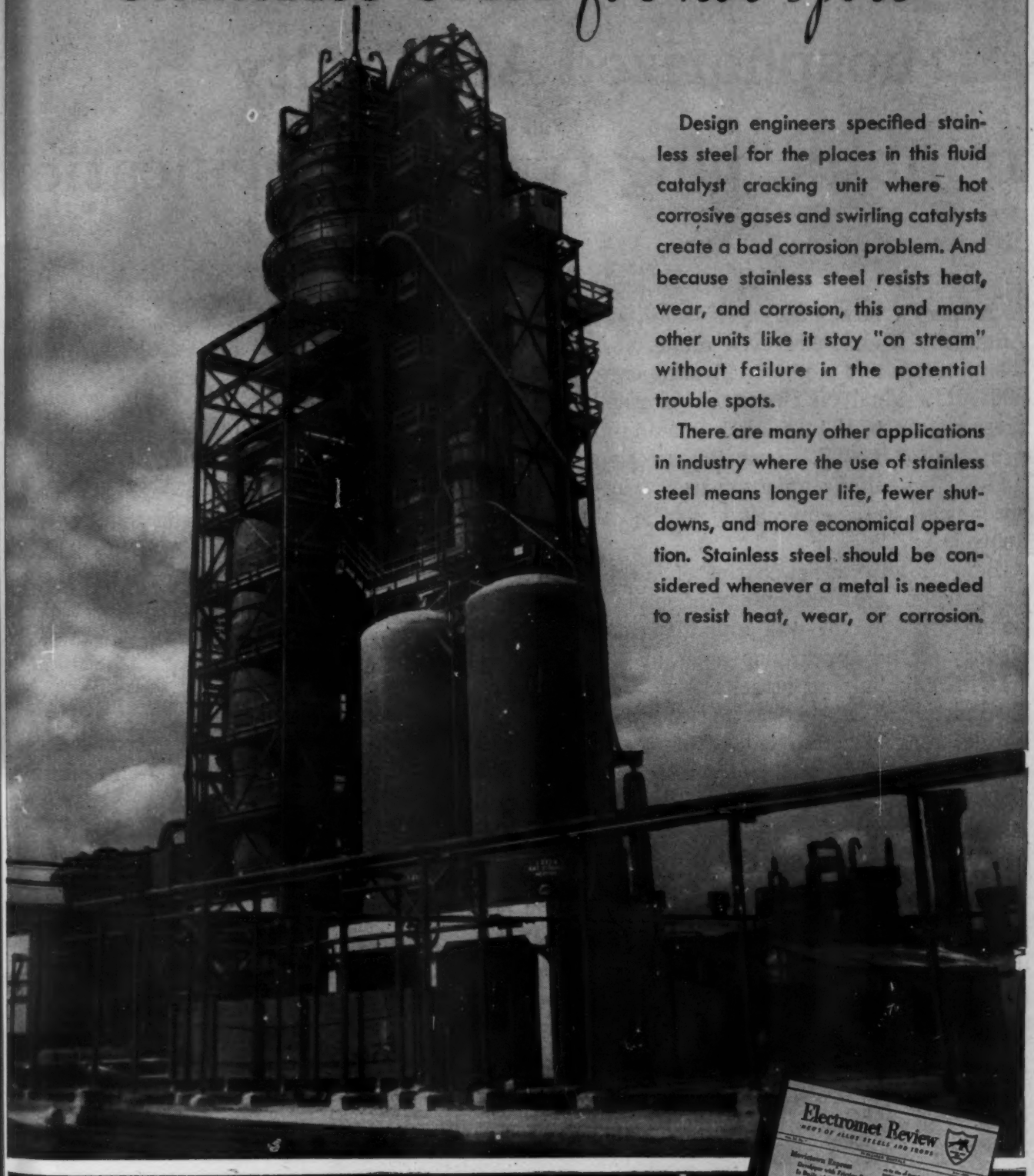
The Brown ElectroniK Potentiometer — Air-o-Line Controller, operating on the **"Continuous Balance"** principle, has obsoleted potentiometers dependent on intermittent correction. Its inherent features—sensitivity, ruggedness, simplicity, and precision—are requisites of modern control instruments.

Exhaustive comparative field tests have demonstrated that **"Continuous Balance"** is the twin of **sensitivity** and that both are required in solving today's petroleum and chemical process control problems.

Write for Catalogs. THE BROWN INSTRUMENT COMPANY, a division of Minneapolis-Honeywell Regulator Company, 4498 Wayne Avenue, Philadelphia 44, Pa. Offices in all principal cities. Toronto, Canada; London, England; Stockholm, Sweden; Amsterdam, Holland.

BROWN *Electronik* POTENTIOMETERS

STAINLESS STEEL *for hot spots*



Design engineers specified stainless steel for the places in this fluid catalyst cracking unit where hot corrosive gases and swirling catalysts create a bad corrosion problem. And because stainless steel resists heat, wear, and corrosion, this and many other units like it stay "on stream" without failure in the potential trouble spots.

There are many other applications in industry where the use of stainless steel means longer life, fewer shutdowns, and more economical operation. Stainless steel should be considered whenever a metal is needed to resist heat, wear, or corrosion.

Other interesting uses of stainless steel are described in ELECTROMET REVIEW, published by ELECTRO METALLURGICAL COMPANY, the Unit of UNION CARBIDE AND CARBON CORPORATION that produces alloys for making steel. If you need this complimentary publication, write on your business letterhead to ELECTRO METALLURGICAL COMPANY, Room 328, 30 East 42nd Street, New York 17, N. Y.

BUY AND HOLD UNITED STATES VICTORY BONDS AND STAMPS

Phosphorized Admiralty inhibits "plug-type" dezincification

A refinery's heat exchanger tubes, of plain Admiralty Metal, conveyed crude oil at 100 lbs. pressure and a maximum temperature of 200°F. Residual oil circulated externally, at pressures up to 125 lbs. and a maximum temperature of 650°F. Because corrosion was limiting tube life to approximately four years, specimens were submitted to Scovill for analysis.

Beneath an internal coating of fairly heavy black scale, consisting chiefly of sulphur compounds, the metal was found to have the slightly etched appearance generally associated with mild sulphur attacks. Also, there was local pitting of the tube walls; two pitted areas on different sections had effected complete perforation and were directly responsible for tube failure. The majority of the pits were formed with redeposited copper, indicating "plug-type" dezincification.

THE ROOT OF THE TROUBLE

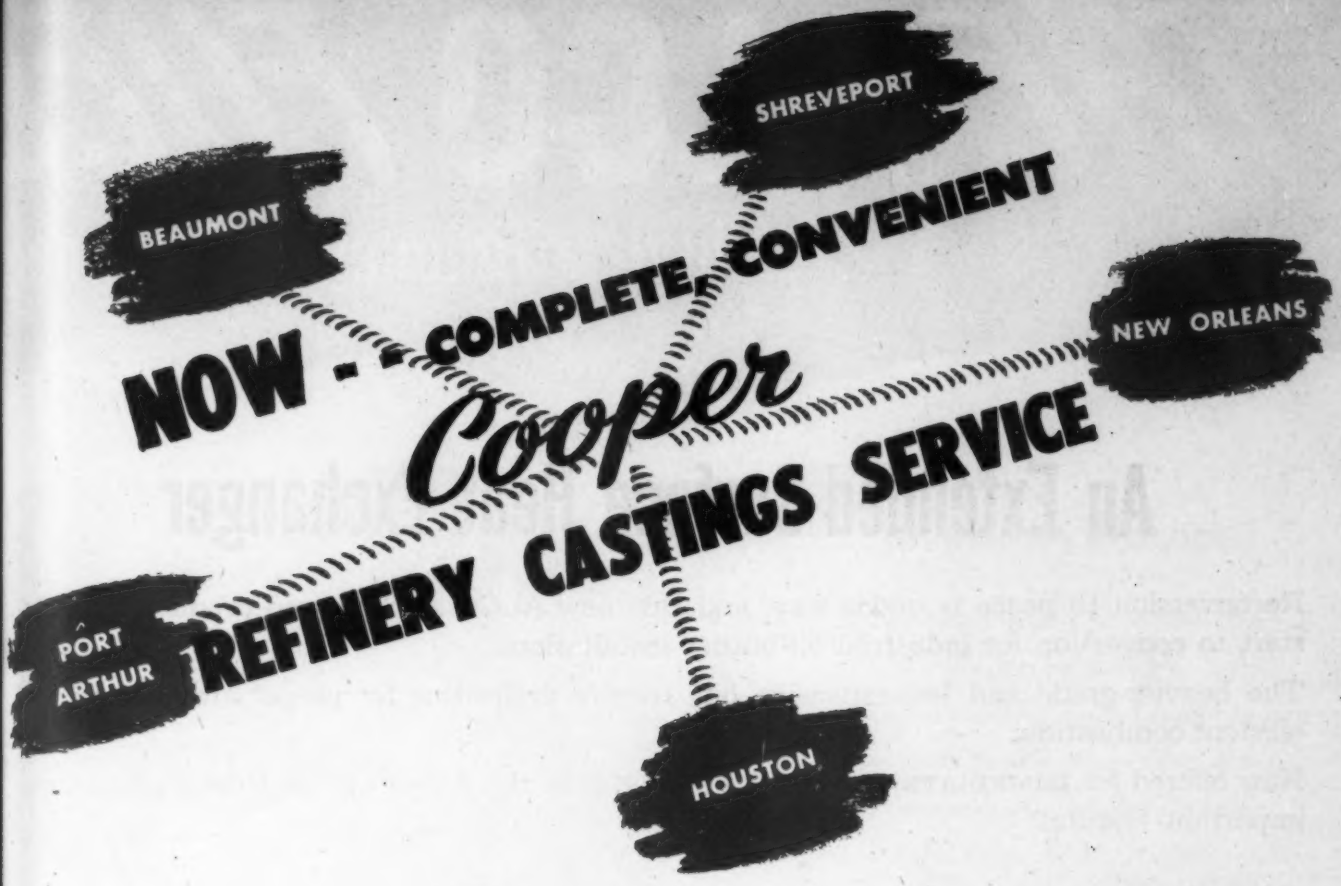
Scovill technicians traced the cause to two underlying factors: relatively high wall temperatures acting on the heavy porous scale resulted in seepage and trapping of the liquid, which in turn caused accelerated dezincification. While the corrosion-resistant properties of plain Admiralty are generally excellent, its resistance to this type of attack is admittedly low. Additional protection for the zinc content is needed.

Accordingly, re-tubing with Phosphorized Admiralty was recommended, since the approximately .04% of phosphorus in this alloy has proved a highly effective deterrent to dezincifying corrosion, with no impairment of the characteristic Admiralty structure or properties.

THREE SCOVILL SERVICES

The above is typical of the specialized consultation on tube problems and installations included in Scovill's *Service in Men*. There are two other Scovill Services. *Service in Metals* develops new alloys in laboratory and field to meet individual needs. *Service in Manuals* offers helpful literature on condenser and heat exchanger tubes. For your copy of the booklet *Scovill Condenser Tubes*, address Scovill Manufacturing Company, 15 Mill Street, Waterbury 91, Connecticut.

Scovill
MANUFACTURING COMPANY
WATERBURY 91, CONN.
CONDENSER TUBES
ONE PRODUCT . . . THREE SERVICES
Service in Manuals . . . Service in Metals . . . Service in Men



Cooper alloy castings have been well and favorably known in the refinery industry for some time past. Corrosion-resistant, heat-resistant headers, return bends, tube supports, valves and fittings produced by Cooper are used today by leading refiners. This specialized service is now brought into the very heart of the oil industry.

Cooper's sales representatives, Standard Brass & Manufacturing Company, has branches in five convenient centers—Port Arthur, Houston, Beaumont, New Orleans and Shreveport. Cooper's specialized refinery engineering and product design service is now conveniently available through the Duffee Engineering Service, Houston, an organization specifically devoted to refinery work. And back of both are the engineering and manufacturing facilities of the completely modern Cooper foundry, machine shop and laboratories in Hillside, New Jersey.

Refinery executives are invited to avail themselves of these convenient services. Inquiries are treated in confidence and incur no obligation.

CA-101

THE ONLY ALLOY FOUNDRY WITH ALL THESE FACILITIES

- Laboratory control over raw materials and finished products.
- Dual foundry . . . both hand and machine molding.
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- Centrifugally-cast castings.
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- Precision Castings.
- Machine shop . . . specially equipped for finishing stainless steel.
- Improved cleaning . . . including Lustracast electrolytic finishing which leaves all surfaces bright.
- Castings furnished rough, polished or fully machined . . . one ounce to two tons.
- Development of special alloys to meet unusual requirements.
- Technical consulting service.

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THE ALCO FUEL

for high efficiency and econom

An Extended-Surface Heat Exchanger

Reconversion to peace is under way, and this new ALCO standardized product is a head start to conversion for industrial oil-burner installations.

The heavier-grade and less-expensive oils require preheating for proper atomization and efficient combustion.

Now offered for IMMEDIATE SHIPMENT FROM STOCK, this Alco Fuel Oil Heater offers these important features:

1. HIGH HEAT TRANSFER DUE TO:

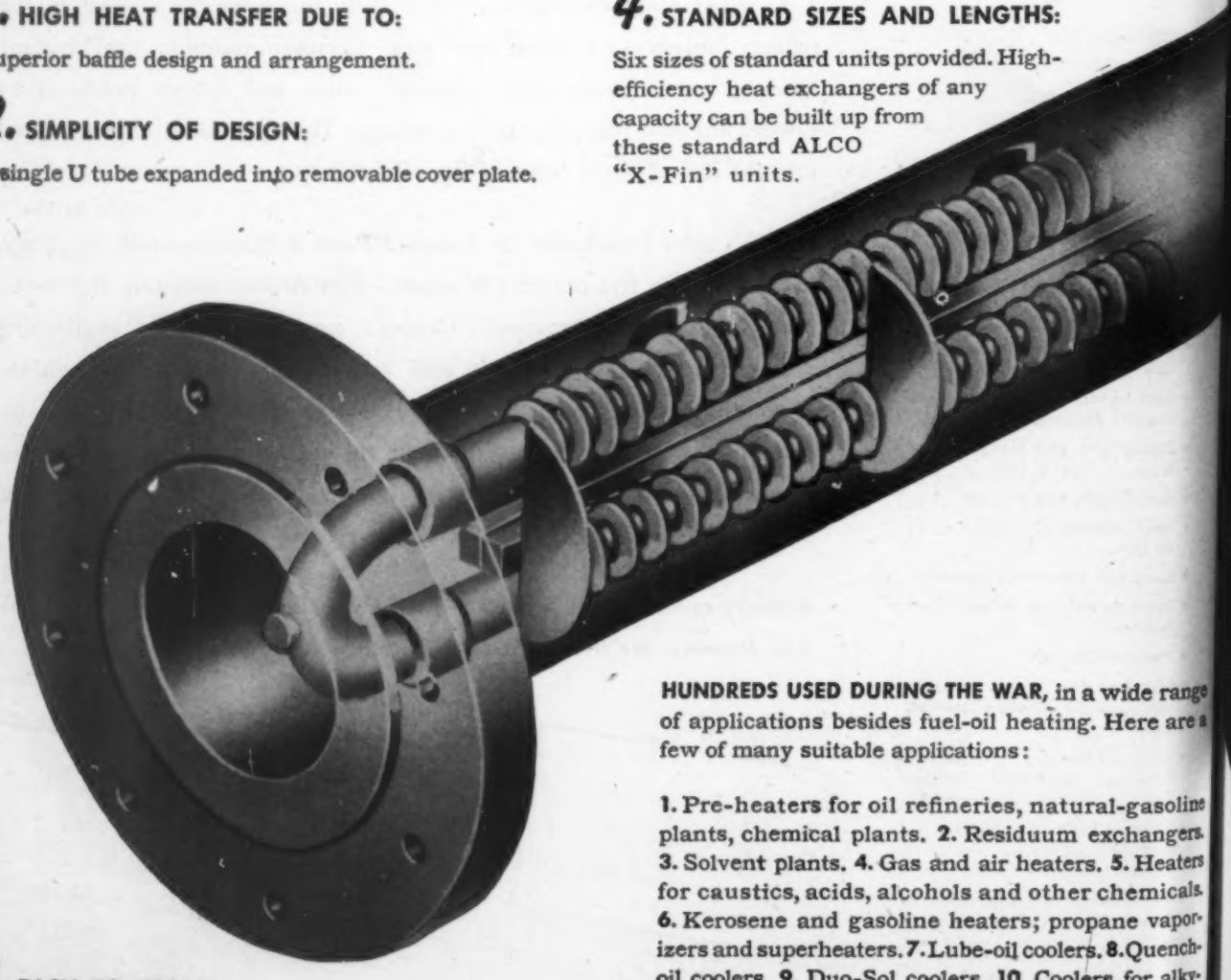
Superior baffle design and arrangement.

2. SIMPLICITY OF DESIGN:

A single U tube expanded into removable cover plate.

4. STANDARD SIZES AND LENGTHS:

Six sizes of standard units provided. High-efficiency heat exchangers of any capacity can be built up from these standard ALCO "X-Fin" units.



3. EASY TO CLEAN:

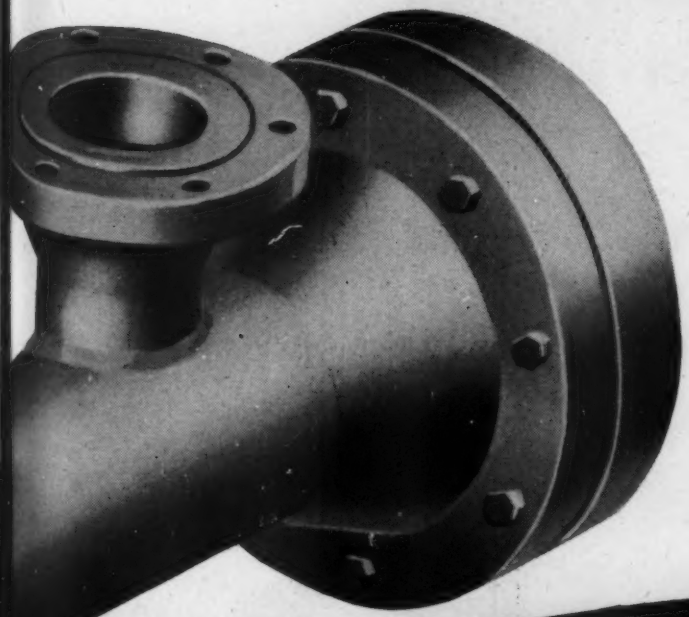
Baffle assembly easily separable from heat-transfer element.

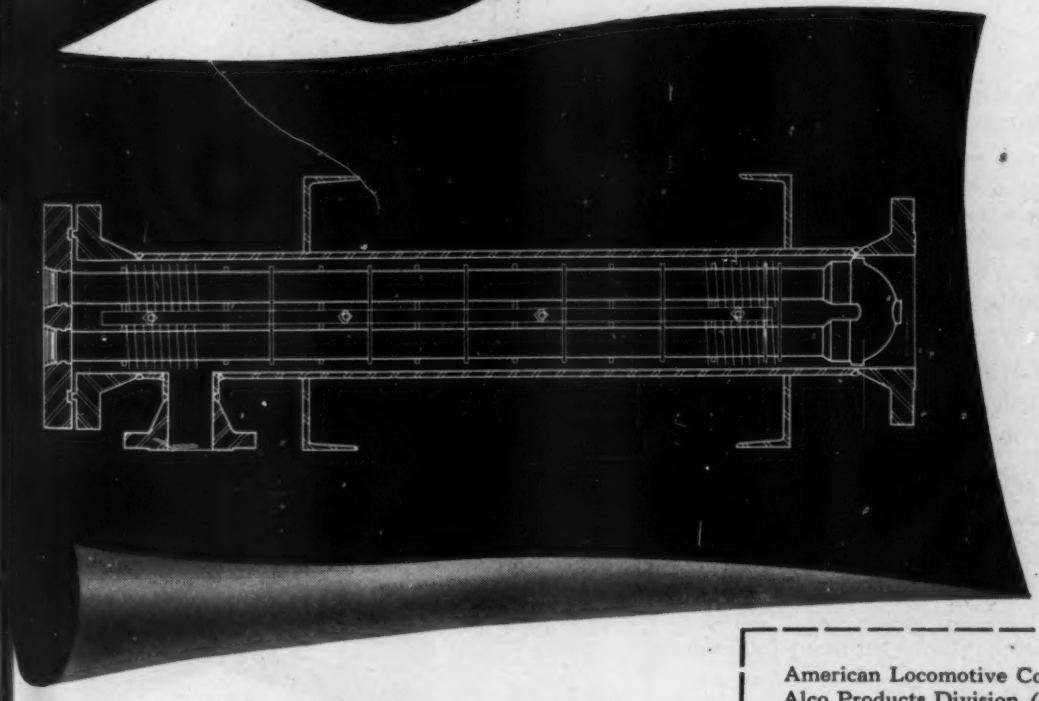
HUNDREDS USED DURING THE WAR, in a wide range of applications besides fuel-oil heating. Here are a few of many suitable applications:

1. Pre-heaters for oil refineries, natural-gasoline plants, chemical plants. 2. Residuum exchangers. 3. Solvent plants. 4. Gas and air heaters. 5. Heaters for caustics, acids, alcohols and other chemicals. 6. Kerosene and gasoline heaters; propane vaporizers and superheaters. 7. Lube-oil coolers. 8. Quench-oil coolers. 9. Duo-Sol coolers. 10. Coolers for alkylation plants. 11. Gasoline and kerosene coolers. 12. Coolers for absorption processes. 13. Gas and air coolers. 14. Compressed-air aftercoolers.

OIL HEATER

space...weight...cost...and maintenance





OTHER ALCO PRODUCTS:

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Weldments

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A copy of the new ALCO Bulletin, No. 1036, describing and illustrating this new line of ALCO products will be sent you promptly, on request. Write for it today.

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Please send me your new bulletin #1036, about the Alco Fuel Oil Heater.

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Dowtherm on the job!

A long-term investment in dependable service

Nine years ago, this big food processing firm looked at a heating problem . . . thought of the future . . . and installed a Dowtherm unit. Their foresight has been paying them dividends ever since in dependable, accurate heating service.

This particular Dowtherm system is used for deodorizing vegetable oils at temperatures of 500° to 550° F. . . . a job well suited to Dowtherm's precise control and low pressure operating characteristics. The unit is gas fired, entirely automatic in operation. It has been a good investment. A recent letter from the superintendent of the plant tells of the steady and satisfactory service this installation is still giving after years of operation.

A record like this will be no surprise to hundreds of other satisfied Dowtherm users. Dowtherm vapor heating covers the range of processing temperatures from 300° to 725° F., with pressure requirements not exceeding 110 lbs. per sq. in. gauge. With its simplicity of operation, low maintenance requirements, and accuracy of control, it is handling difficult heating problems for many industries.

Dowtherm may bring speedier production, reduced upkeep costs, and greater product uniformity to your processing operations. Just drop a line to Dow for further information.

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The high-temperature low-pressure heat transfer medium

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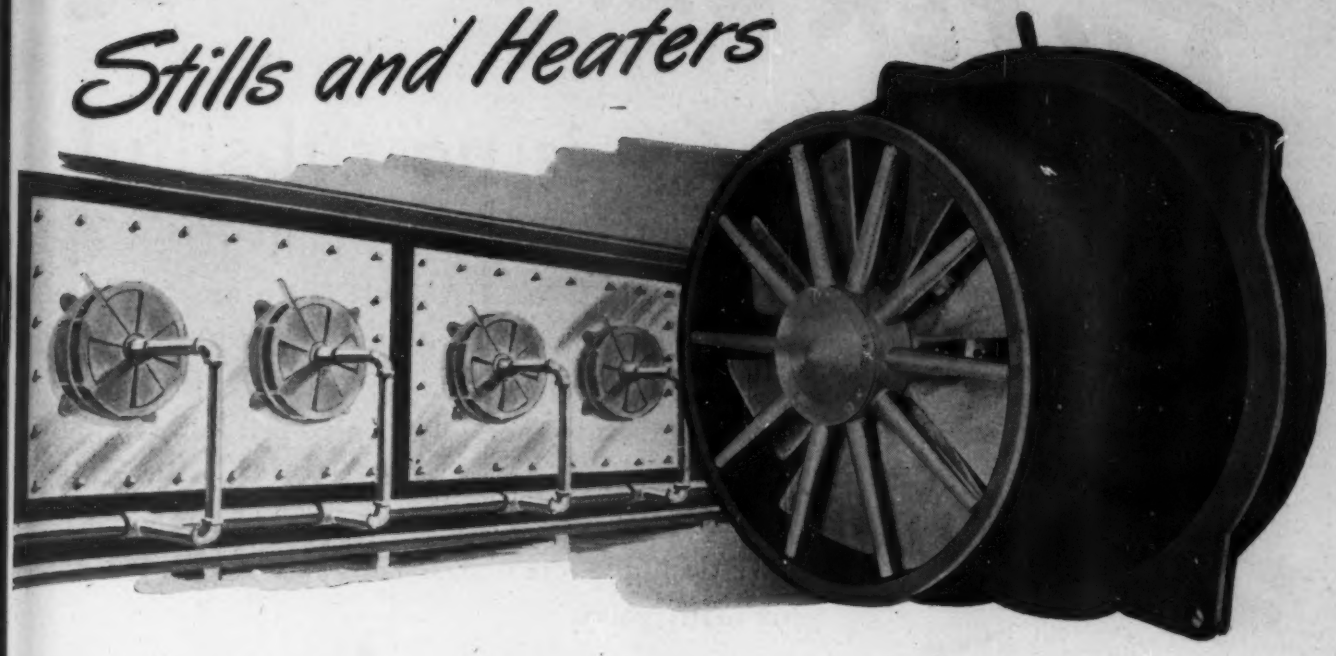
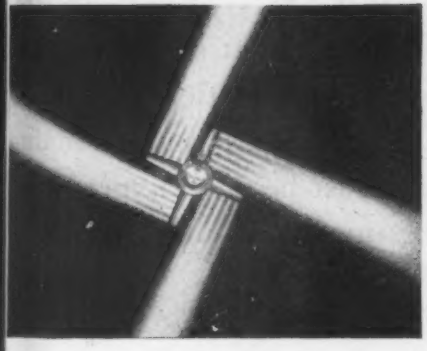
CHEMICALS
INDISPENSABLE TO INDUSTRY

"BUNSEN'S DREAM" UPS THRU-PUT OF

Stills and Heaters





Bunsen, developer of the first gas burner, believed that "An ideal gas burner is one in which there would be an infinite number of gas orifices interposed across the air stream." And that is as close a description as you could get of the Coppus-Dennis FANMIX Burner.

The exclusive "pinwheel action" principle of FANMIX produces a perfectly combustible mixture of air and gas that results in:—

1. Complete combustion with less than 5% excess air.
2. Greater heat release.
3. Total absence of drifting "hot spots"

Here's how FANMIX works. Fuel escaping from orifices in rotating driver arms, rotates the fan which draws in air at right angles to the path of the fuel. The energy of the fuel under pressure is utilized to perform work by mechanically mixing and proportioning the fuel with just the required amount of air.

Increase Rating of Old or New Equipment

Coppus engineers FANMIX Burners for individual application. Complete control over rate of combustion or flame pattern can be provided to meet requirements of any installation. Straight gas and combination gas-oil burners available; combination burners burn either oil or gas in entirety or in any proportion. No oil guns needed.

Send for the Coppus-Dennis FANMIX Bulletin 410-4. Coppus Engineering Corporation, 292 Park Ave., Worcester 2, Mass. Sales offices in THOMAS' REGISTER. Other Coppus "Blue Ribbon" products in SWEET'S, CHEMICAL ENGINEERING CATALOG, REFINERY CATALOG.

On New Installations, Fanmix Saves

1. **COMBUSTION SPACE.** With FANMIX the furnace does not have to serve as a mixing chamber.
2. **STACK HEIGHT.** With FANMIX there is no draft loss across the burner.
3. **INSTALLATION COSTS.** With FANMIX you can use smaller pipe sizes, need no forced draft equipment, etc.

More than 93% of 191 petroleum refinery plants built for war, use Coppus equipment.

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EXPERIENCE VS. EXPERIMENTATION

GOSLIN-BIRMINGHAM DEWAXING FILTERS are time-proven, not just the 'attempts' at producing acceptable equipment. Refinery production schedules cannot be altered at will . . . schedules must be maintained and operating costs must be met. Experimentation with equipment of unproven merit is costly business, ruinous in many cases.

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BUYER BEWARE

New-comers in the Filter manufacturing field have admittedly selected G-B FILTERS as their model for imitation. Investigation and study are the only means of determining the marked superiority of GOSLIN-BIRMINGHAM FILTERS over the products of embryo enterprise.

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for our Children and our Children's Children

Now, let's win the Peace

In our thankfulness that the most terrible war in history is ended, let us not forget the sacrifices of those who won it, and the sorrow of those whose loved ones will not come back.

And let us "highly resolve that these honored dead shall not have died in vain". Let each man, woman and child in this great land resolve that this peace shall endure, so that our children, and our children's children, may be spared the catastrophic consequences of another war.

Let's win the Peace — with Justice and Good Will.

The Men and Women of

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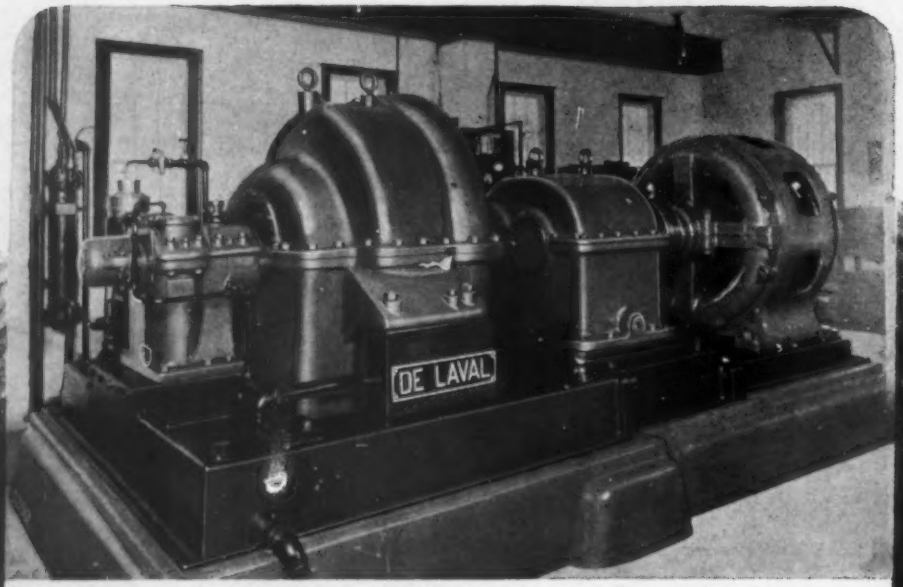
One of the Dresser Industries

SEVENTEEN YEARS OF UNINTERRUPTED SERVICE



De Laval two-stage centrifugal compressor with speed-increasing gear, installed in the Houston Sewage Treatment Plant, where it delivers 12,000 c. f. m. against 6 lb. pressure at 3600 r. p. m. compressor speed and 1200 r. p. m. motor speed.

...not one minute for Repairs!

Since September, 1927 when this De Laval motor-driven geared compressor was placed in service in the City of Houston Sewage Treatment Plant, it has operated better than 99 per cent of the time, without ever requiring repairs or overhauling.

Such operation is typical of De Laval dependability. De Laval water works pumps installed more than thirty years ago still give excellent service. De Laval geared turbine ship propulsion units have traveled upwards of 2,000,000 miles without requiring major repairs; and De Laval worm reduction gears have operated for years hidden in the abrasive dust of cement plants.

M-50

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Application of Bridgeport's Arsenical Admiralty tubing in Griscom-Russell Company's K-Fin heat exchanger. Fins were fastened to the tubes by the manufacturer.

...For Long Service Life

Corrosion is a most important factor in oil refineries where condensers and heat exchangers must handle petroleum products—hydrocarbon gases containing sulphur compounds, gasoline and naphtha vapors, and lubricating oils—salt or fresh circulating water, hot gases and air.

For these conditions Bridgeport's Arsenical Admiralty has been found to give most satisfactory all 'round service—more freedom from dezincification because it contains the necessary proportion of arsenic; longer service life, and greatest overall economy.

Bridgeport offers a wide variety of condenser tubing for many applications in petroleum refineries and petroleum-chemical plants—Arsenical Muntz*, copper, 70-30 cupro nickel, Cuzinal (aluminum brass), Duronze** IV (aluminum bronze) and red brass.

For conditions too severe for a single metal or alloy Bridgeport developed Duplex Tubing—copper-base tubes combined with tubing made from carbon or stainless steel, aluminum, monel metal or other alloys.

Much data accumulated from Bridgeport's research on corrosion problems and condenser tube life as well as information on modern condenser tube alloys is contained in a 112-page Condenser Tube Manual, available for the asking. Please send your request on company stationery.

*Reg. U.S. Pat. No. 2118688
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Condenser and Heat Exchanger Tubing

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* District offices and stores.
** Sales Office.
*** Pipe Depot.

FACTS YOU SHOULD KNOW ABOUT U.O.P.

The service that Universal Oil Products Company offers is so broad in scope that not everyone realizes its extent and the importance of each of its activities.

Top management may think of us only as the originators and licensors of its refining processes. Engineers may tell you that we design refinery equipment. Operators and maintenance men may know us primarily as a servicing and inspection organization. The fact is, we're all of these... and more. Here, in brief, is a resumé of the services which UOP offers to the Petroleum Industry.

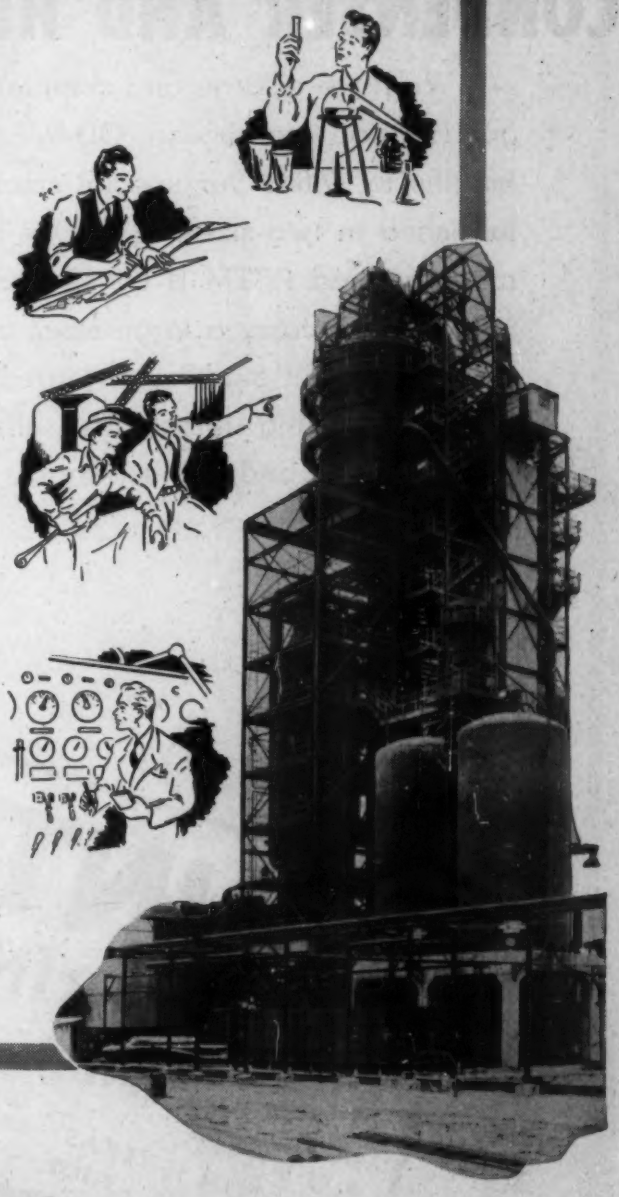
PROCESSES: We are constantly engaged in research and experimentation to improve the processes of petroleum refining. Universal scientists have been responsible for many of the major improvements in modern refining processes including thermal cracking, catalytic cracking, polymerization, alkylation, isomerization, hydrogenation, dehydrogenation, and others. The processes which we develop are available to all refiners.

ENGINEERING: In order to assure proper results from the processes which we develop, we assume full responsibility for the design of all necessary equipment.

SUPERVISION: While we do no construction ourselves, we do provide competent engineers who devote their time to careful inspection of the construction and erection of the equipment which we design.

SERVICING: Once the plant is on stream, one of our most important activities... Servicing... starts operation. This includes, first, an intensive training program to impart to operating men an exact knowledge of the operation of the new equipment. Second, we send expert operating men periodically to the licensee's refinery to check yield and render counsel and advice. Third, we maintain a most efficient inspection organization composed of specially trained men who are continually in the field making physical inspection of licensed units and recommending such steps as may be necessary to insure continued high efficiency.

Thus, not only does Universal provide the original process and live with the job until it is on stream, but continues to maintain a lifetime interest in its efficient, economical operation.



UNIVERSAL OIL PRODUCTS COMPANY

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CONDENSER AND HEAT EXCHANGER TUBES

We have a large and complete stock of tubes for prompt shipment from our Houston warehouse. OD-5/8" through 2", gauges 16 BWG to 6 BWG, lengths to 37'6". Our special stock of long tubes from 32'0" to 37'6" can be furnished in two sizes, 3/4" OD x 14 BWG and 1" OD x 12 BWG. All tubes manufactured ASTM A-179-42 and A-83-42.

We also carry a large stock of seamless pipe, including large OD pipe and alloy steel stud bolts; forged and cast steel valves and forged steel fittings, including unions, tees, ells, crosses, reducers, return bends, flanges; regulators; oil and gas separators; gas, oil and water meters; orifice fittings and pressure gages.

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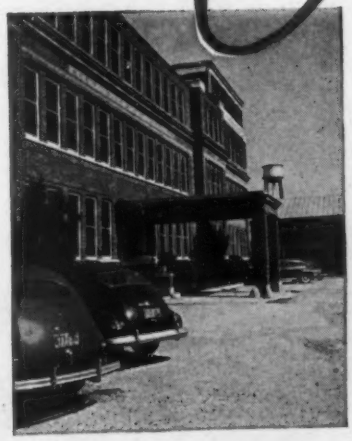
MECO

Greetings of the Season



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ROLLER BIT COMPANY

CROLL-REYNOLDS EVACTORS

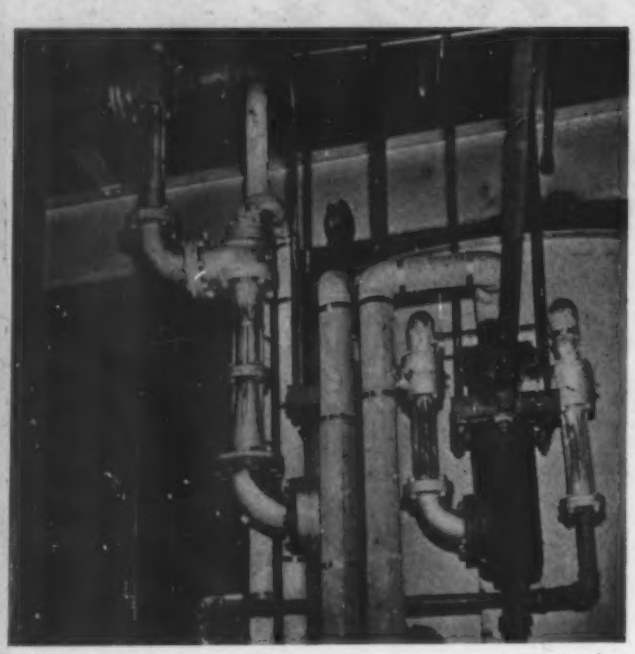
for

efficient

and

dependable

HIGH VACUUM



The above view shows an operating installation of a 4-stage Evactor serving a still handling a high boiling organic material at an absolute pressure of one tenth of 1 mm. In this plant, as in so many others using Croll-Reynolds Steam Jet Evactors, a duplicate installation was made when capacity had to be increased.

Evactors are available in single and multi-stage units of various types and are serving a wide variety of requirements in the petroleum and chemical industries, including vacuum refrigeration and vacuum cooled heat exchangers.

CROLL-REYNOLDS ENGINEERING CO.

17 JOHN STREET NEW YORK 7, N. Y.

AMERICA'S largest selling PUMPS Provide Water For Industrial Service, Domestic Uses & Irrigation • Peerless offers the most complete line of vertical and horizontal pumps. Because of the extensiveness of the line, a pump of the size and exact type best suited for your pumping conditions, which makes for greatest economy of operation, is available to you. The Hi-Lift illustrated here is furnished in sizes of from 500 to 3,500 gallons per hour. The Hydro-Foil (Propeller Type) up to 220,000 gallons per minute.

DOMESTIC WATER SYSTEMS

The Water King, **shallow well type, utilizing the HI-LIFT principle ingeniously applied in simplest form, in sizes up to 1,300 gallons per hour. The Peerless Jet Pump, for deep or shallow wells, is available in sizes up to 5,000 gallons per hour.**

Peerless Distributors and Direct Factory Representatives Located In All Principal Cities

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PEERLESS PUMP DIVISION
Food Machinery Corp.

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The GUESS IS OUT WHEN YOU MEASURE YOUR VALUABLE STORED LIQUIDS With LIQUIDOMETER Tank Gauges

WRITE for COMPLETE DETAILS

"LIQUIDS WORTH STORING ARE WORTH MEASURING"

THE LIQUIDOMETER CORP.
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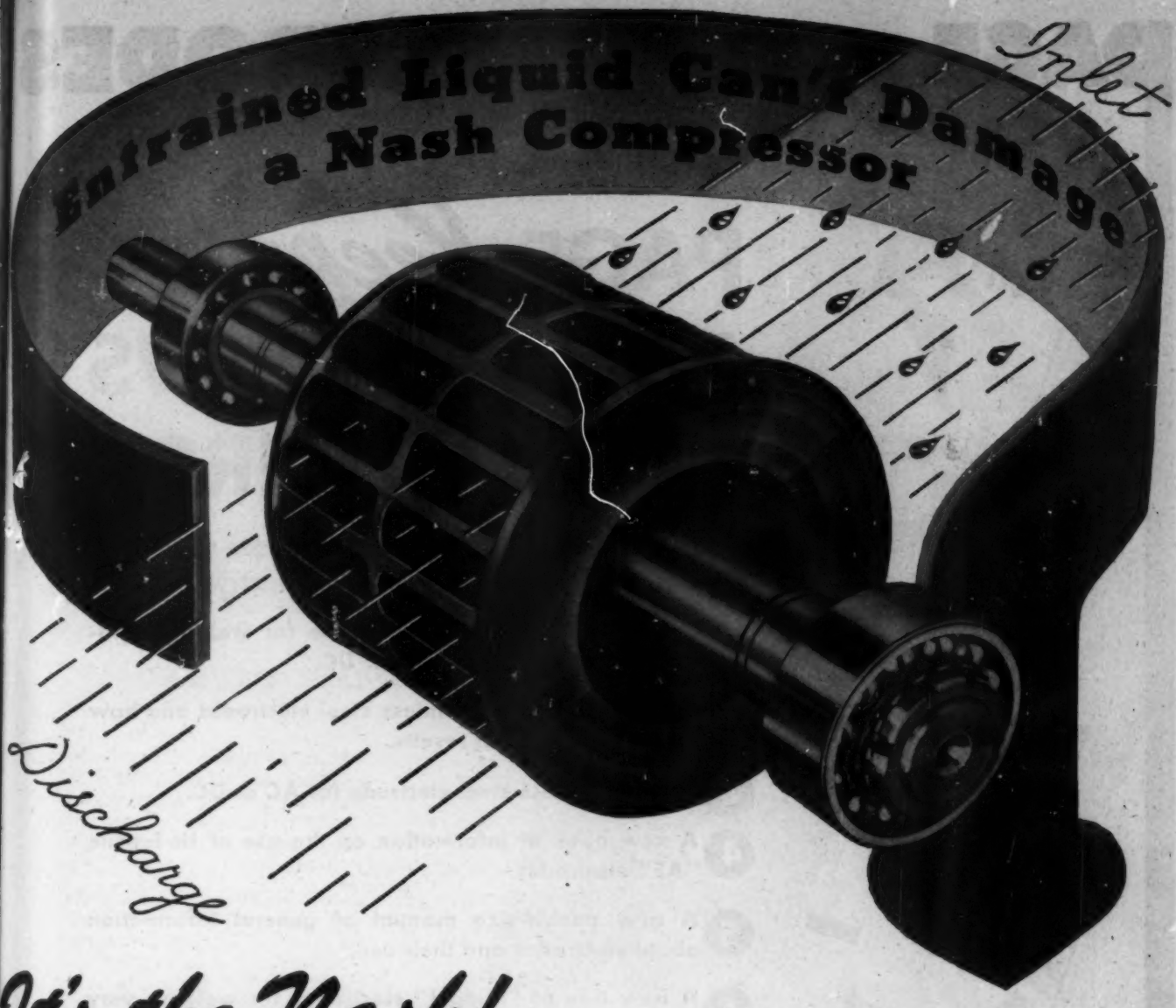

It's the Nash!

The ability of Nash Compressors to maintain original performance thruout a long life is only one of the many advantages which derive from the Nash liquid piston principle of compression.

Since this liquid piston is an integral part of the Nash Compressor, additional liquid can do no harm to the pump structure, whether in the form of slugs entering by accident, or as condensate forming in the suction lines. In handling gases, for example, wet hydrocarbons, usual elaborate protective devices are eliminated. The hazards of such devices are therefore avoided, the cost of installation is saved, and freedom from repairs and shutdowns is assured.

Nash Compressors produce 75 lbs. pressure, or vacuums to 26 in. of mercury, in a single stage, with capacities to 6 million cubic feet per day in a single structure. They have but one internal moving part, simple and non-wearing. There are no valves, gears, pistons, sliding vanes, or other enemies of long life. No gas contaminating internal lubricant is employed. Compression is without pulsation. It will be to your advantage to investigate the Nash Compressor.

26 in. mercury vacuum or 75 lbs. pressure in one stage.

No internal wearing parts.

No internal lubrication to contaminate gas handled.

Desired delivery temperature automatically maintained.

Non-pulsating pressure.

Original performance constant over a long pump life.

Low maintenance cost.

NASH ENGINEERING COMPANY

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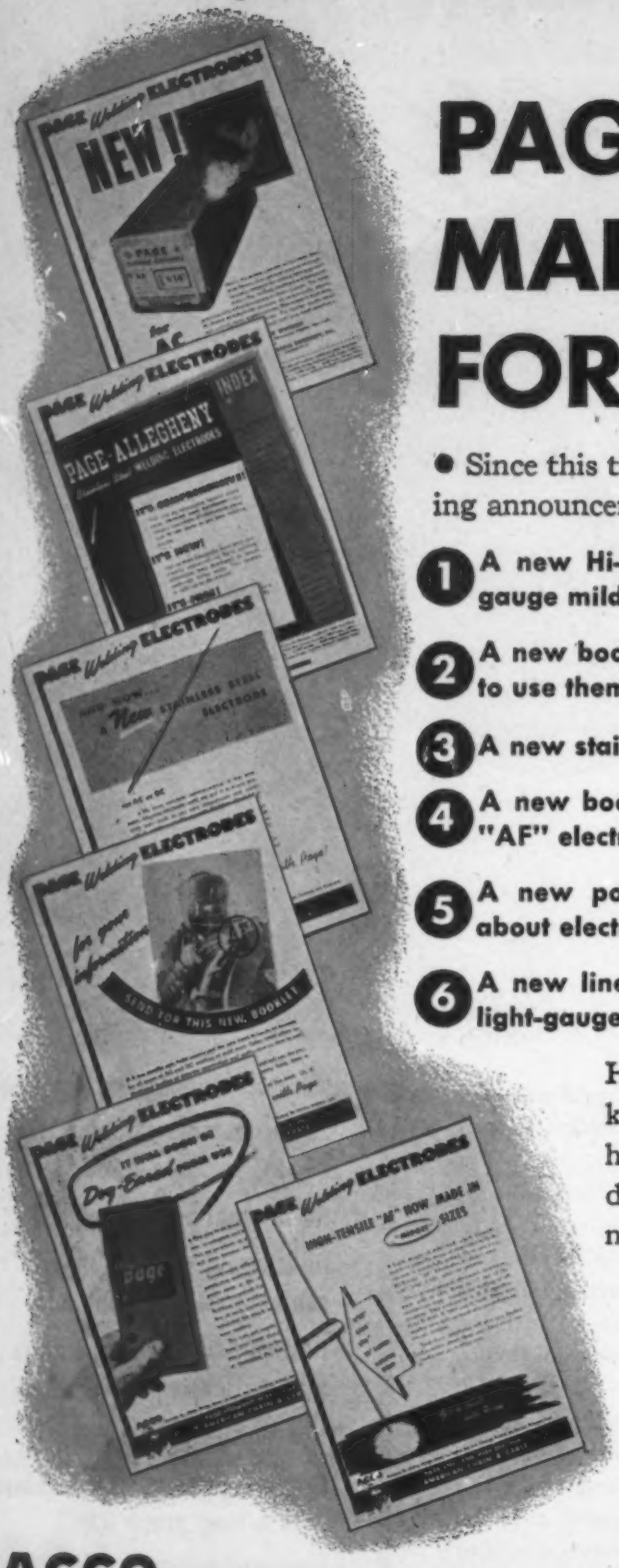
PAGE *Welding* ELECTRODES



PAGE *Keeps On* MAKING NEWS FOR WELDERS

• Since this time last year, PAGE has made the following announcements to the welding industry:

1. **A new Hi-Tensile "AF" electrode for welding light-gauge mild steel, using AC or DC.**
2. **A new book about stainless steel electrodes and how to use them for best results.**
3. **A new stainless steel electrode for AC or DC.**
4. **A new book of information on the use of Hi-Tensile "AF" electrodes.**
5. **A new pocket-size manual of general information about electrodes and their use.**
6. **A new line of "midget" electrodes for welding very light-gauge mild steel.**

Here is tangible evidence that PAGE is keeping up with the times. For uniformly high quality electrodes and for up-to-date information about welding techniques, it will pay you to . . .

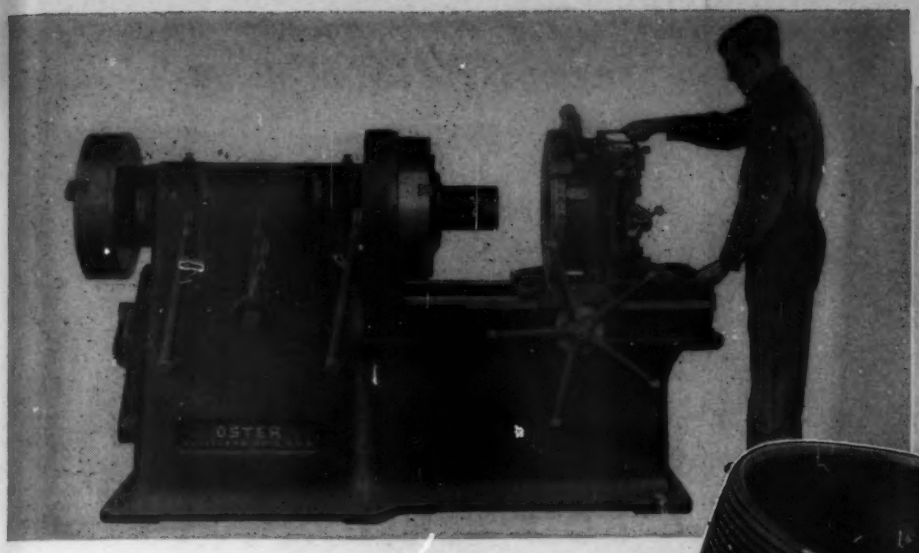
Get in touch with Page!

ACCO

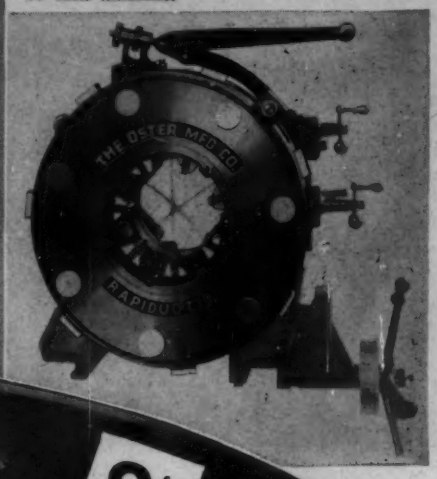
Monessen, Pa., Atlanta, Chicago, Detroit, Denver, Los Angeles, New York, Pittsburgh, Portland, San Francisco, Bridgeport, Conn.

PAGE STEEL AND WIRE DIVISION
AMERICAN CHAIN & CABLE

ACCO TRADE MARK



Oster "RAPIDUCTION" die-head adjusted to thread largest size of pipe within range of each machine.



One Die-Head

THREADS THEM ALL!

Movement of cam lever on the "RAPIDUCTION" die-head sets chasers for any size pipe to be threaded. Micrometer adjustment of lever sets chasers for any depth of thread desired.

Threading speeds of Oster "RAPIDUCTION" machines range from only 11.3 seconds on 1½" pipe to only 3 minutes, 10 seconds on the big 12" pipe. Those speeds are maintained on a continuous production basis.

Three Models

No. 6-A "RAPIDUCTION." Standard range 1½" to 6" pipe. Bolt range 1" to 4".

No. 8 "RAPIDUCTION." Standard range 2½" to 8" pipe.

No. 12 "RAPIDUCTION." Standard range 3½" to 12" pipe.

If you have large quantities of pipe to thread, Oster "RAPIDUCTION" machines will prove to be a profitable investment.

Oster "RAPIDUCTION" die-head adjusted to thread smallest size of pipe within range of each machine.

OSTER

"Rapiduction" PIPE MACHINES

THE OSTER MANUFACTURING COMPANY, 2029 EAST 61st ST., CLEVELAND 3, OHIO, U. S. A.

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ADSORBENTS

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GASKET FAILURE

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3. No other gasket can surpass Flexitallic for service under high or low temperatures, high or low pressures, gases, chemicals or other difficult conditions.

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including the 2500 lbs. A. S. A. Series

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SUPERIOR to any other filter in flexibility and versatility. Puts you ahead of changes that tomorrow may bring. Provides unusual efficiency and economy. Already field-tested over a broad range of applications.

WIDE VARIETY OF FILTERING MEDIA

Design permits use of media to suit practically every requirement. Any medium—metallic, plastic, or fabric—that comes in sheet form and can be crimped may be used. Tested media include types resistant to both hot and corrosive liquids; also types to remove dirt particles down to 2 microns (.000078") or less in size.

NEW *SLIP-ON* INSERT FOR QUICK CHANGE OF MEDIUM

METHOD OF REMOVING SLIP-ON INSERT

An entirely new idea in the application of filtering medium, the STAYNEW SLIP-ON INSERT, permits quick change or replacement of medium.

LOW FIRST COST, LOW MAINTENANCE COST

Volume production of a basically economical design means low initial cost. Ease of cleaning or replacement of medium mean low maintenance cost.

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The well-known Staynew Radial Finned Insert Construction provides the largest possible filtering area for available space.

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Model ELS Filters handle a total of 105,000 gallons per minute in one large industrial plant.

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REPRESENTATIVES IN PRINCIPAL CITIES

STAYNEW PROTECTOMOTOR FILTERS

DOLLINGER CORPORATION

Silver ANNIVERSARY 1920-1945

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with Super-Silvertops

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On any installation, simplified piping with Anderson Super-Silvertops saves fittings and labor. On every installation, you get maximum heat and long, trouble-free trap life. Find out all about it; get your copy of "How to Choose a Steam Trap" . . . This helpful book tells where, when and why to use steam traps, what size, what type and in what way to install them. It shows how Anderson Super-Silvertops are constructed and points out the savings. Ask for your copy—it's free!

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All-purpose, heavy-duty tachometer with large 4" dia. dial; lightweight, durable and serviceable for industrial applications of all kinds. Aluminum housing; tachometer mounted by means of mounting holes in four ears of housing. Wide variety of R.P.M. ranges available.

Write for Descriptive Bulletin 44-I

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1. FORGED STEEL CASE—Supported at the center-line to prevent distortion caused by changes in temperature—vertically split with ring type joints to assure tightness under all pressures and temperatures. May be lined with corrosion resistant material when necessary.

2. REMOVABLE END COVERS—Of forged steel.

3. DEEP WATER-COOLED STUFFING BOXES—With renewable throats—reduce wear and prolong life of packing.

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5. DIFFUSERS—Efficiently convert velocity energy to pressure energy—assure perfect radial balance.

6. POSITIVE STAGE-TO-STAGE SEAL—Seals face-to-face and metal-to-metal—all interior gaskets eliminated.

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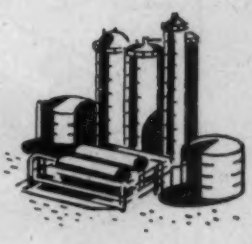
RATING—Designed for speeds up to 3600 R.P.M.

Sizes—2 to 8 inches.

Capacities—75 to 2700 G.P.M.

Differential Pressures—up to 2500 lbs.

Operating Temperatures—up to 800° F.

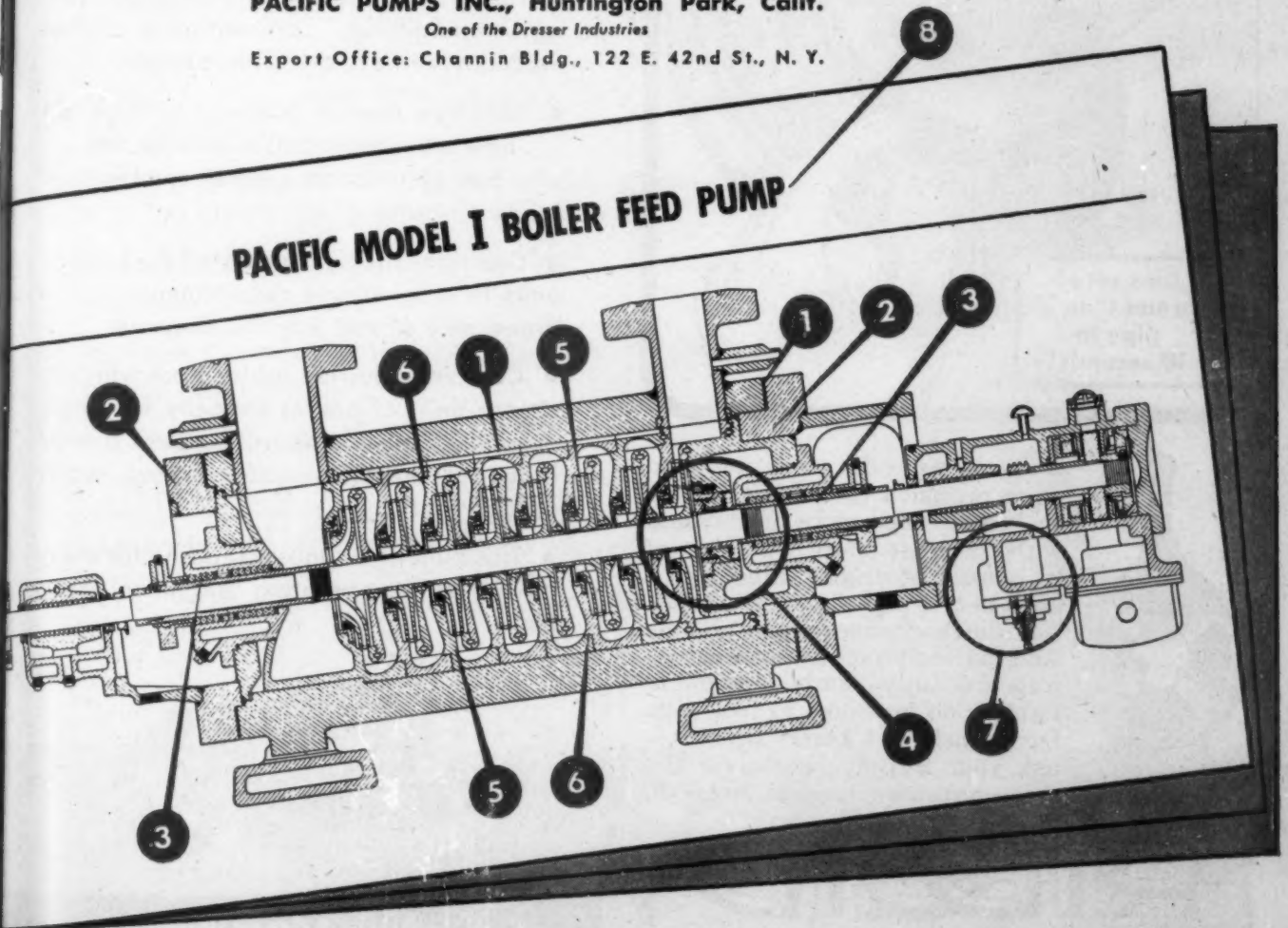


Write for Pacific Pumps Bulletin 80

PACIFIC PUMPS INC., Huntington Park, Calif.

One of the Dresser Industries

Export Office: Channin Bldg., 122 E. 42nd St., N. Y.

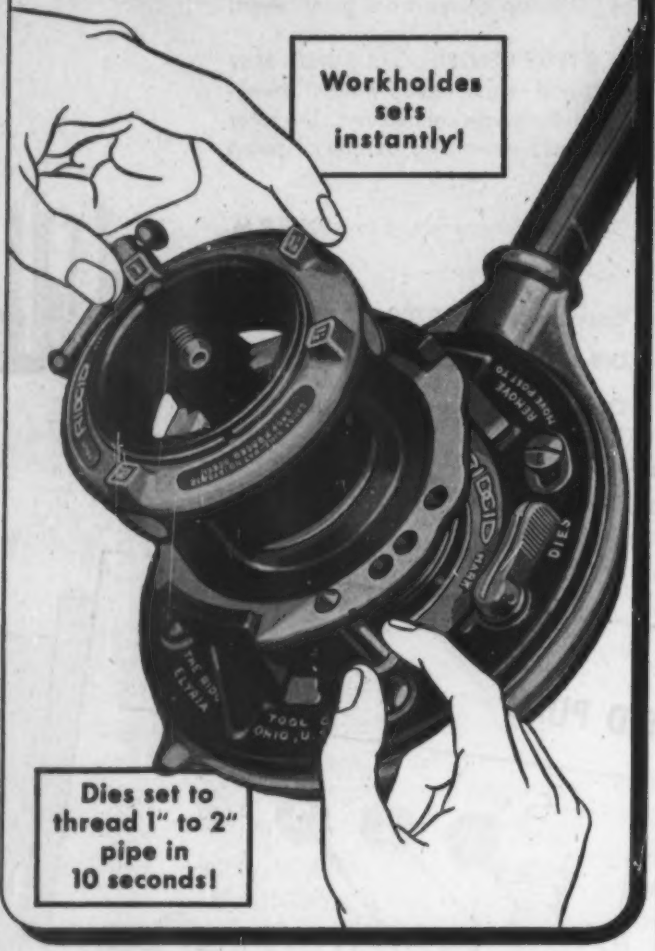


PACIFIC *Engineered* PUMPS

You thread pipe with the utmost ease and speed

with semi-automatic self-contained

RIDGID No. 65R



It stands up handily on the floor.

● This popular die stock gives you clean precision threads on 1," 1¼," 1½" and 2" pipe more quickly and with the least effort. For 1 set of high-speed steel dies threads all 4 sizes, sets to pipe size in 10 seconds—no dies to change or carry around. And its foolproof workholder adjusts instantly—only 1 screw to tighten, no bushings to fool with. Save work, get better threads—ask your Supply House for the self-contained RIDGID No. 65R.

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Send for this

New . . . **Bulletin on Boiler Water Chemical Treating Units . . . . . .**

- Tells how to protect boilers against corrosion and pitting . . . prevent scale, control alkalinity, remove dissolved oxygen.
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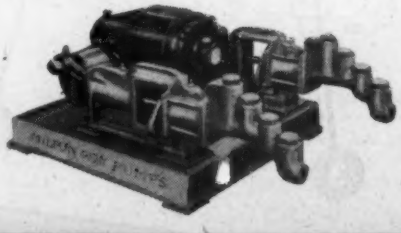
- Describes simple, complete "Packaged" units to meet above requirements . . . a brand new Milton Roy development.
- Contains selection tables from which to choose units of proper capacity for single or multiple boilers operating over a wide range of pressures and make up water requirements.
- This bulletin is "must" reading for every power plant operating engineer. Send for it.



MILTON Roy PUMPS

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"That is not clear. Why? . . . There is some foreign matter in it . . . some matter that we do not want . . . GET IT OUT!

Gravity Settling is TOO slow . . . and all too often it is INCOMPLETE.

Use Centrifugal Force . . . it is FAST . . . it breaks stubborn mixtures.

Sharples Centrifugal Force has a power 13,000 times greater than gravity.

Get Sharples . . . and you'll get not only scientifically designed and precision-made equipment . . . but what is even more important, you will get the benefit of more than 30 years Centrifugal Process Experience.

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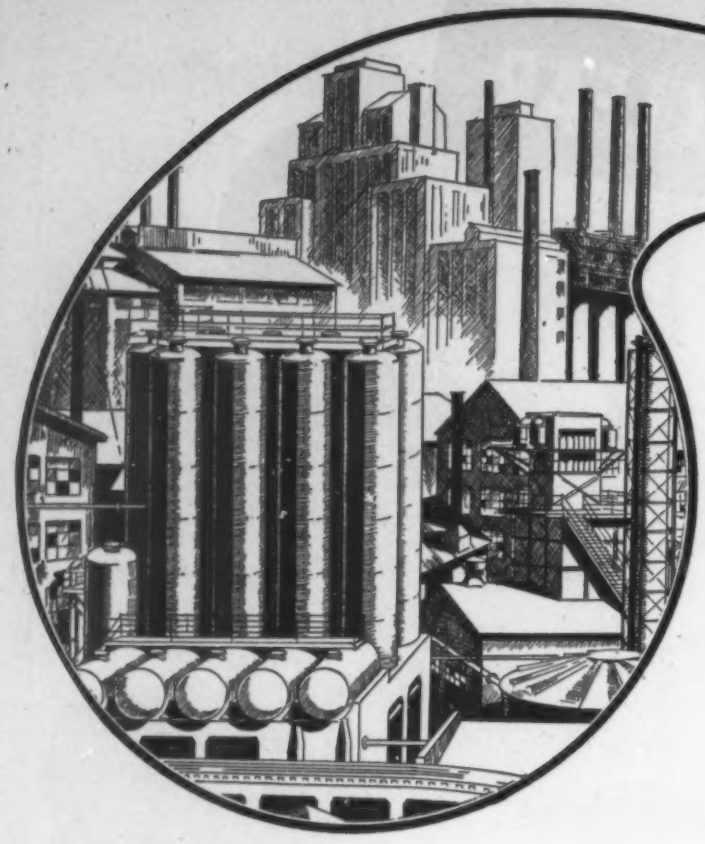

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The 31 years that have elapsed since the establishment of CHEMICO have seen a continuous and rapid development in petroleum refining processes.

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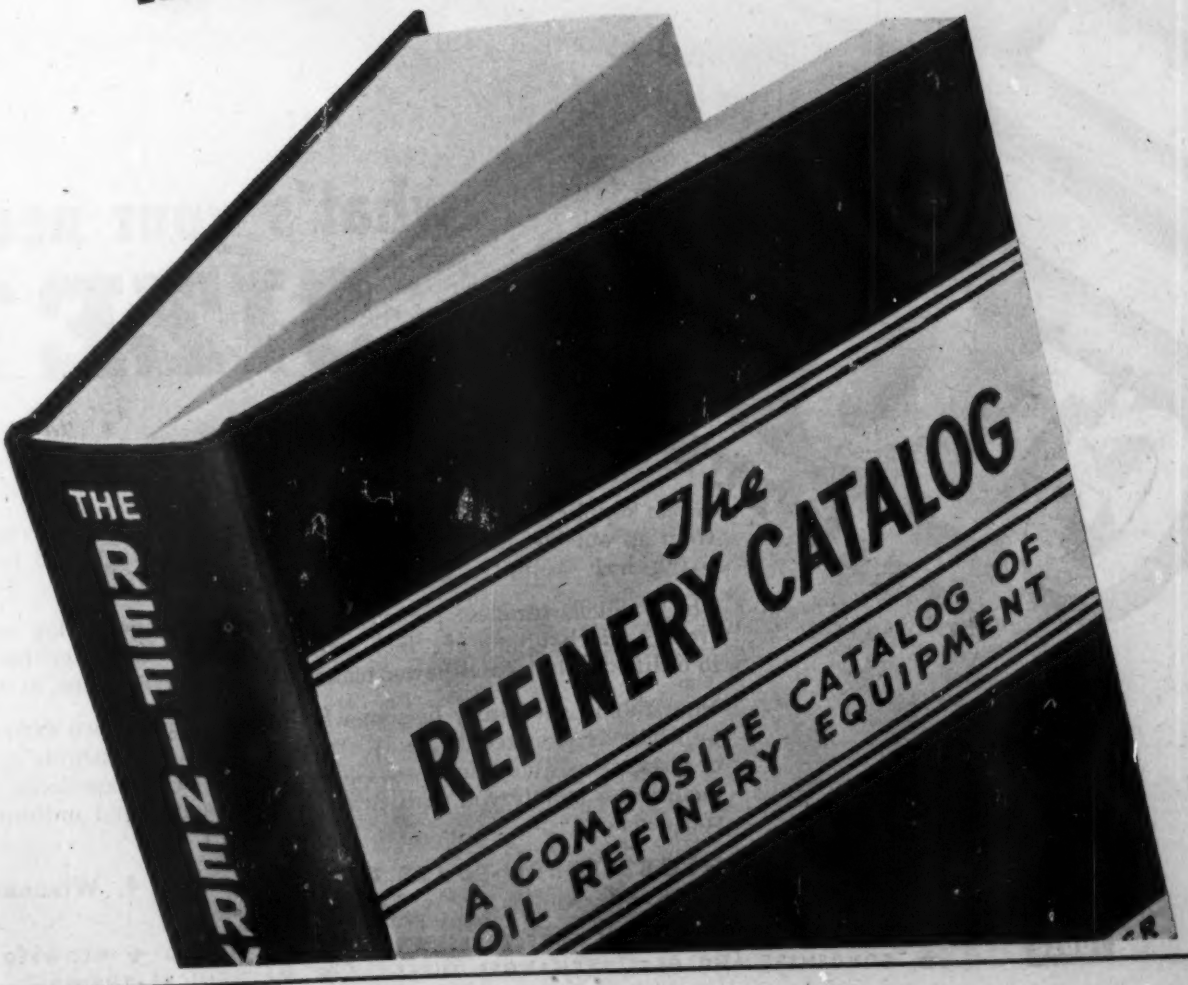

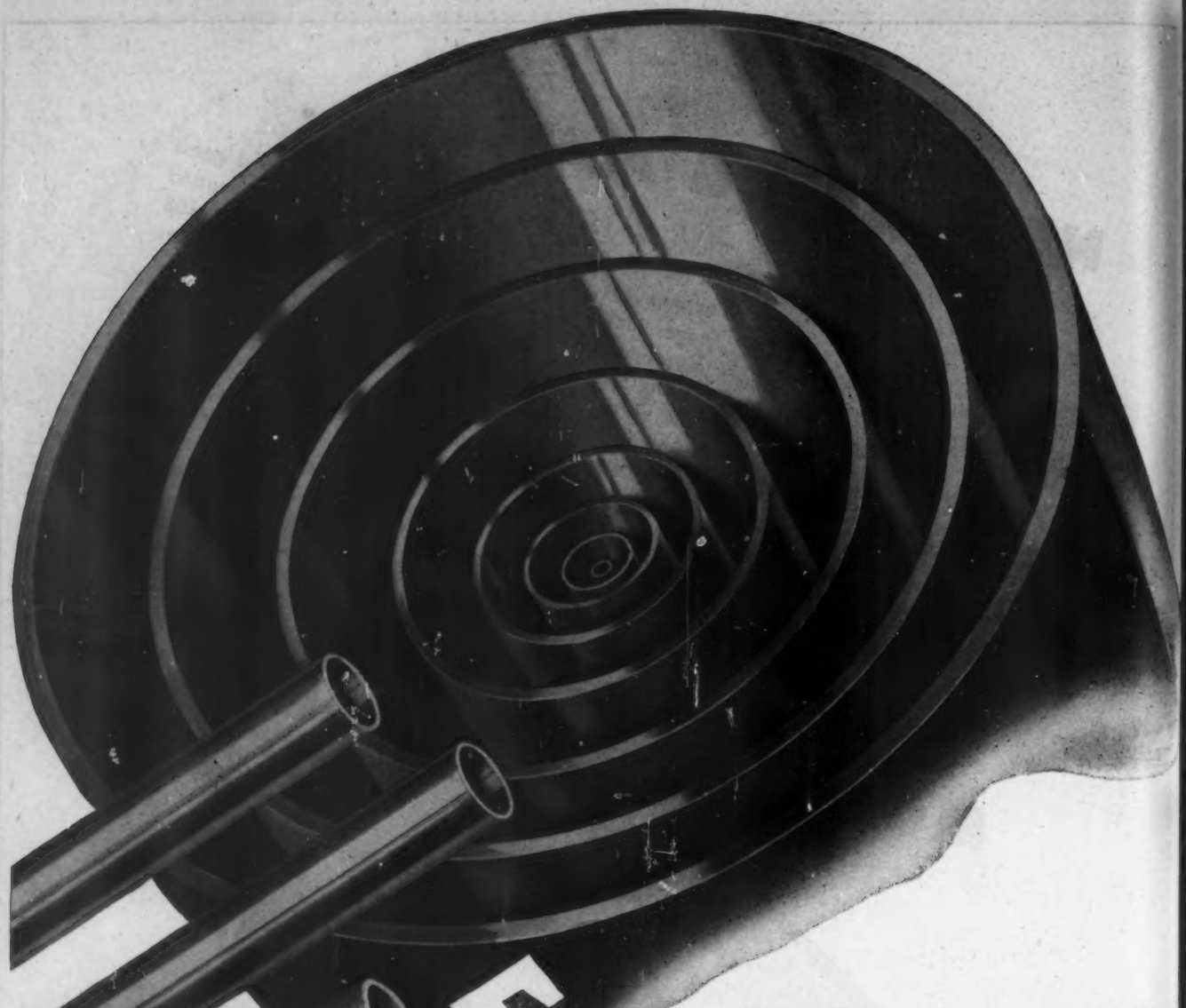

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what's your need in SIZE?

Globe supplies seamless and welded stainless steel tubing ranging from an outside diameter less than that of an average lead pencil — ⅛ inch — up to 6 inch outside diameter (Iron Pipe Size).

Thick-walled, seamless pressure tubes in carbon and alloy steels from ½ inch up to 6⅝ inch outside diameter for huge boilers in utility and industrial power plants are supplied by Globe, as well.

Your tubing needs may lie somewhere between these two extremes — whatever your requirements, standard or special in a wide range of sizes, shapes, and analyses, Globe is qualified by experience and facilities to supply you with tubing of the quality and uniformity you demand.

GLOBE STEEL TUBES CO., Milwaukee 4, Wisconsin

GLOBE TUBES

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★ CONDENSER AND HEAT EXCHANGER TUBES ★ MECHANICAL TUBING

5025

Change to HOMESTEAD LEVER-SEALD "Stick-Proof" QUARTER TURN VALVES

Corrosive or viscous fluids cannot "stick" HOMESTEAD LEVER-SEALD QUARTER-TURN VALVES because all vital operating parts and valve seating surfaces are protected in both open and closed positions. Only during the instant of operation is a small area of the valve plug exposed to line contents; and any fluid adhering to this momentarily exposed portion is instantly wiped off as the plug turns from one position to the other. Corrosion or erosion of seating surfaces is therefore reduced to a minimum.

Additional assurance of easy, stick-proof operation under all temperature, pressure and fluid conditions, is the exclusive built-in *lever-seald* mechanism, a part of every Homestead Lever-Seald Valve. The lower lever relieves seating pressure between valve plug and body just enough to overcome friction and permit easy turning. Then a *quarter-turn* of the upper lever opens or closes the valve. Seating pressure is again applied with the lower lever to make a positive, leakless seal.

HOMESTEAD LEVER-SEALD QUARTER-TURN VALVES provide instant, trouble-free operation, longer service life and greatly reduced maintenance costs. Order them in sizes from 1½" to 10" for pressures from 150 to 1500 lbs. in metals matched to service requirements. Write for Valve Reference Book No. 38.

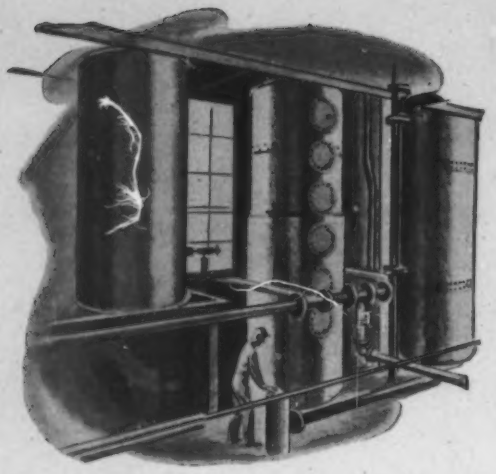
6 REASONS WHY HOMESTEAD LEVER-SEALDS ARE BETTER VALVES

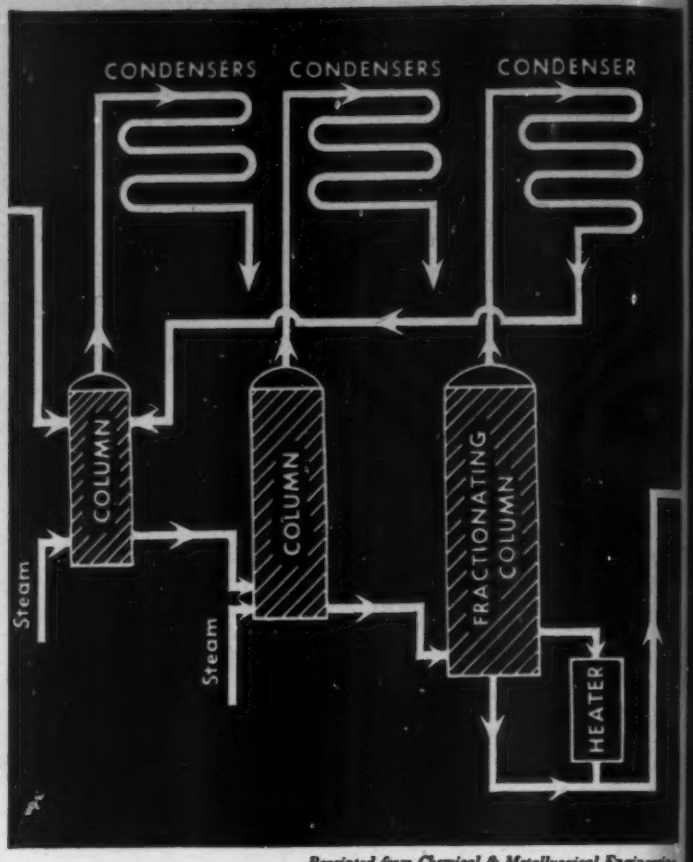
1. Instant stick-proof operation.
2. Quarter-turn fully opens or closes.
3. Positive seal without lubrication.
4. Seating surfaces always protected in both open and closed positions. Corrosion practically eliminated.
5. Unobstructed straight-line fluid flow.
6. All operating parts protected from damaging effects of service conditions and weather.

"M" Pennant with two additional gold stars — Maritime's highest production award to our men and women making valves for the Victory Fleet.

Homestead V LEVER-SEALD VALVES

HOMESTEAD VALVE MFG. CO. . . . P. O. BOX 16 . . . CORAOPOLIS, PA.





Reprinted from Chemical & Metallurgical Engineering

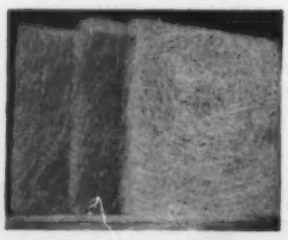
FIBERGLAS* helps cut fractionation costs...speed production

Chemical engineers, by utilizing Fiberglas Tower Packing in fractionation columns, are speeding production, cutting costs and improving products. They are also obtaining the economies and advantages of Fiberglas in distillation, evaporation, diffusion and in contact and eliminator processes.

Fiberglas Tower Packing is made of glass fibers approximately .0080" in diameter, bonded with a water soluble binder to form packs 20" x 20" x 1". The fibers, being glass, are non-hygroscopic, are unaffected by most acids, and will withstand temperatures up to 1000° F. They will not shrink, stretch, rot or decay. Because the fibers are smooth and cylindrical, resistance to the flow of liquids is comparatively low. The interstices between fibers can be controlled, to provide almost any degree of porosity, by the choice of fiber size and density of pack.

Why not investigate the advantages of Fiberglas Tower Packing in connection with your own process? We shall be pleased to furnish samples and technical information. Write: *Owens-Corning Fiberglas Corp., 1956 Nicholas Building, Toledo 1, Ohio.*

In Canada, Fiberglas Canada Ltd., Oshawa, Ontario.



Fiberglas Tower Packing, made of fibers of glass, affords such advantages as:

Light Weight: Densities from 2½ to 6 pounds per cubic foot are being used to obtain desired surface areas.

Large Surface Area: Ranging from 135 sq. ft./cu. ft. at a density of 3½ pounds per cu. ft. to 232 sq. ft./cu ft. at a density of 6 pounds per cu. ft.

Large Free Volume: 97.75% per cu. ft. at 3½ pounds density or 96.1% per cu. ft. at the 6-pound density.

Large Free Cross Section: Little pressure is required to send vapor through the tower.

Mechanical Strength: Water-soluble binder provides rigidity for easy handling during application.

Small Weight of Liquid Retained: Exceptionally small, varying with the viscosity of liquids involved.

High Productivity: Low resistance results in greatly increased production per column.

Surprisingly Low Cost: Considerably less than commonly used packing materials.

Readily Available: Made of native materials, obtainable without delay.

FIBERGLAS TOWER PACKING

*T. M. Reg. U. S. Pat. Off.

Why we recommend REVERE Condenser Tubes

Revere copper was used to cover the dome of Boston State House, to roof Old North Church and to fashion boilers for Robert Fulton's steamboat Claremont.

A hundred years of experience went into Revere copper before most of us were born.

Revere Admiralty Condenser Tubes, all of the arsenical type, are today considered standard* in refinery operations everywhere.

There is no record of failure due to dezincification in Revere Arsenical Admiralty Condenser Tubes.

Nor has any case of intercrystalline corrosion ever been observed in commercial installations.

You rightly expect good service from Revere Tubes, as from all other equipment available through your Jones & Laughlin Supply Store.

*Revere also makes special alloy Condenser Tubes and Heat Exchanger Tubes, to cope with unusually severe operating conditions. We maintain warehouse stocks of copper, brass and steel tubes at Tulsa and Houston, with execellent facilities for cutting and burring.

JONES & LAUGHLIN SUPPLY COMPANY

Subsidiary of Jones & Laughlin Steel Corporation

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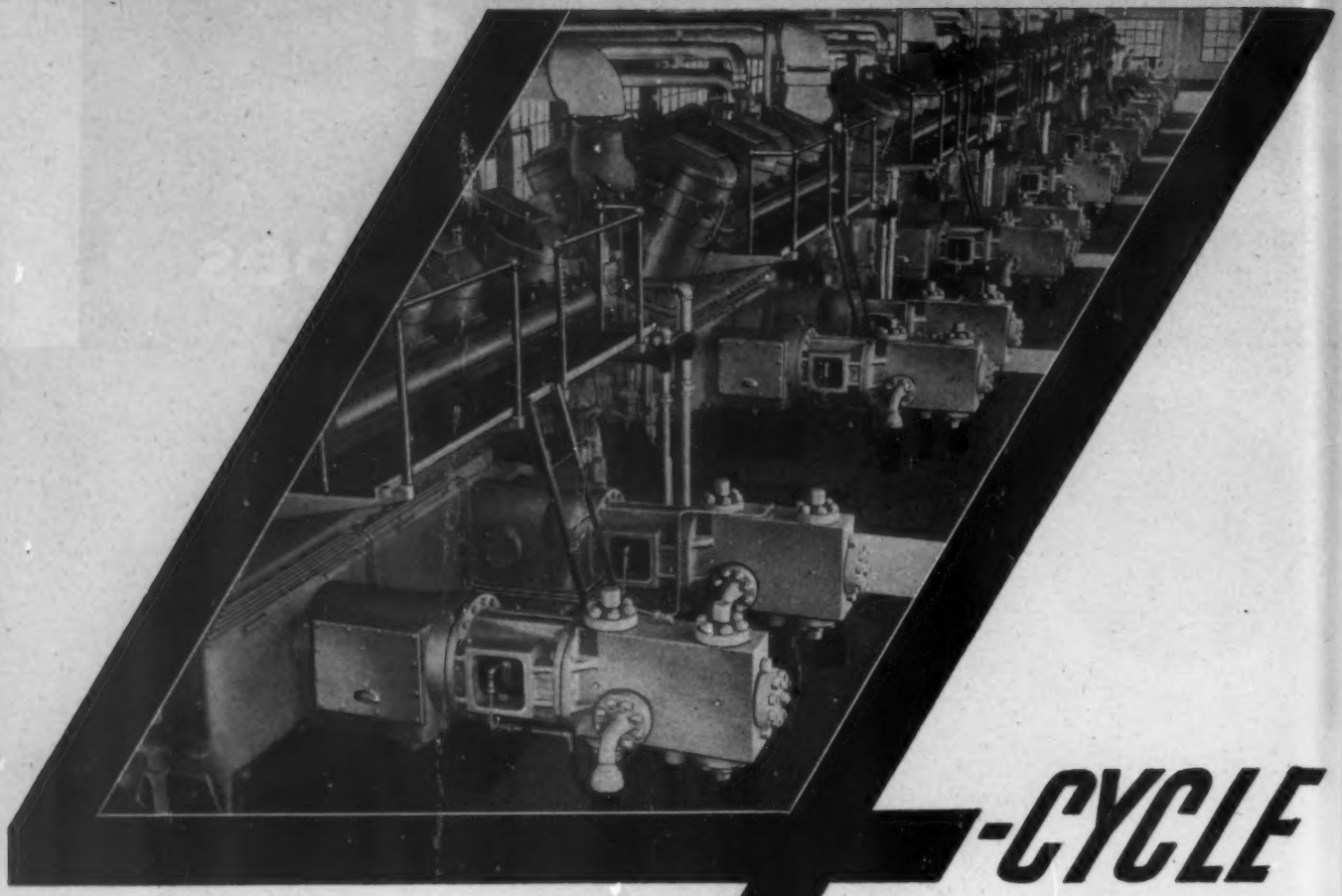
J&L STEEL



4-CYCLE GAS-ENGINE COMPRESSORS

The 4-CYCLE V-ANGLE Line

Here is what Ingersoll-Rand 4-cycle V-angle design is bringing gas-engine operators and owners throughout the petroleum industry: flexibility of speed control . . . ability to handle surging pressure loads . . . simplicity . . . and overall operating economy (fuel, lubricating oil, maintenance, and attendance).

The *first* successful angle gas-engine compressors were 4-cycle . . . built by Ingersoll-Rand. Today this famous line includes 4 sizes of Type XVG, 75 to 300 hp . . . and 5 models of Type KVG, 600 to 1000 hp. Gas engines using the same power cylinders range from 185 to 1200 hp.

The 4-cycle V-angle line is serving cycling and pressure-maintenance systems, gas lift and gasoline plants, pipe lines, refineries, rubber plants, chemical plants, and industrial centers wherever gas is available for fuel.

Ingersoll-Rand

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COMPRESSORS • TURBO BLOWERS
ROCK DRILLS • AIR TOOLS
CONDENSERS • CENTRIFUGAL PUMPS
OIL AND GAS ENGINES

This Name Plate

Attached to Your Heat Exchanger Equipment Assures

CHECK your next installation on all these important points to see if it measures up to the guarantee behind the Lummus name plate. Lummus heat exchangers are supplied in all pressure ranges employed in modern power plants, refineries and other industries. Each unit is especially designed and manufactured for the particular service for which it is intended.

Lummus engineering service is always available for the study of specific heat exchanger problems. For further information write to: The Lummus Company, 420 Lexington Avenue, New York 17, N. Y.

- Sound design
- Rugged construction
- Uniform operation
- Dependable service
- Long life
- Ease of maintenance
- Standardized parts — simplify replacements
- Full efficiency guaranteed
- Extensive servicing facilities
- Class A workmanship

THE LUMMUS COMPANY
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Lummus
HEAT EXCHANGER DIVISION

FACILITIES TO DO THE JOB!

Manufacturers and fabricators of all types of welded sheet and steel plate products. Facilities to do the job whether large or small. Engineering skill backed by constant research.

All equipment is designed, manufactured and supervised by men who have had many years experience in steel plate construction.

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T.E.M.A. HEAT EXCHANGER STANDARDS

The Tubular Exchanger Manufacturers Association fosters the interests of the users and manufacturers of heat exchangers with respect to the best practices in design, engineering and manufacture of tubular heat exchangers. The standards of the Association assist the engineer interested in Thermal and Mechanical Design.

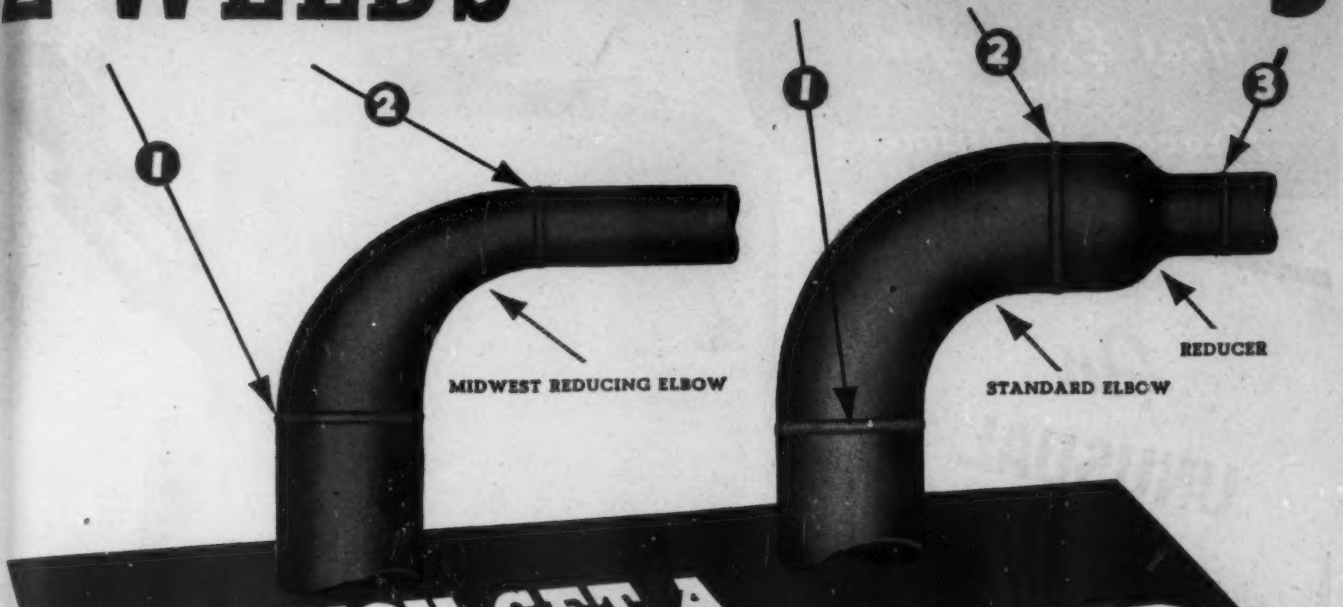
★

A Limited Number of Copies of "Standards of Tubular Exchanger Manufacturer Association" in Heavy Cloth 8½" x 11" Bindings are available at $2.00 per copy (postpaid).

TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION

366 MADISON AVENUE
NEW YORK 17, N. Y.

2 WELDS INSTEAD OF 3



AND YOU GET A BETTER PIPING JOB

MIDWEST

REDUCING WELDING ELBOW

- SAVES WELDING
- SAVES MONEY
- SAVES TIME
- REDUCES TURBULENCE
- IMPROVES APPEARANCE

One weld is eliminated when the Midwest Reducing Elbow is used to change both direction and pipe size in a welded pipe line . . . you make only two welds instead of three. This exclusive Midwest Fitting takes the place of both a standard elbow and a reducer, as shown above. This saves time and money, produces a smoother, cleaner, better appearing job. In addition, the gradual reduction, smooth curve and absence of abrupt neck reduce turbulence. Insulation is also easier.

All the advantages of Midwest Standard Elbows are to be found in Midwest Reducing Elbows . . . unusual dimensional accuracy, beneficial effect of working metal in compression, stress relieving, etc. Center-to-end dimensions are the same as for standard elbows with which they are interchangeable.

This reducing elbow is one of many Midwest Welding Fittings designed to reduce the cost and improve the quality of welded piping. Write for Bulletin WF-41 for complete information.

MIDWEST

PIPING & SUPPLY COMPANY, Inc.

Main Office: 1450 South Second St., St. Louis 4, Mo.

Sales Offices: New York 7—30 Church St. • Chicago 3—645 Marquette Bldg. • Los Angeles 33—520 Anderson St. • Houston 2—229 Shell Bldg. • Tulsa 3—533 Mayo Bldg. • Atlanta 3—Red Rock Bldg. • South Boston 27—426 First St. • Distributors in Many Cities.

MIDWEST WELDING FITTINGS IMPROVE DESIGN AND REDUCE PIPING COSTS

PATTERSON-KELLEY
Heat Exchangers
AND
Process Equipment

An UNUSUAL KETTLE WAS NEEDED *..here it is!*

A prominent processing company asked our engineers to design a blending kettle which had to meet special structural and operating requirements.

Here is the kettle and here are a few of its special features:

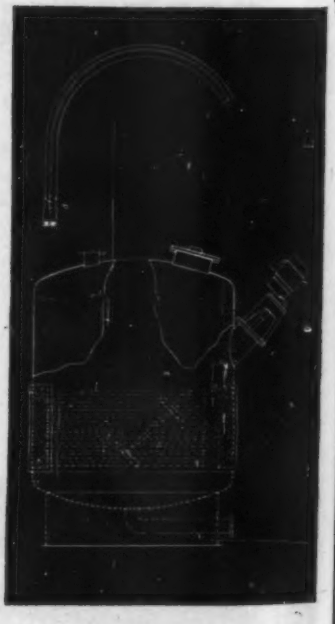
1. heat transfer requirements called for unusually high steam pressure; to withstand the pressure, jackets would have to be so thick that the weight would be undesirable; so

2. coils involving much less metal were designed to handle the pressures to be used, thereby reducing total weight from 18,500 pounds to 6,500 pounds; and

3. these coils were designed in two semi-circular units so that they could be withdrawn for cleaning and maintenance through side ports. Lack of head room prevented the use of customary circular coils

4. lack of head room ruled out the customary stirrer location

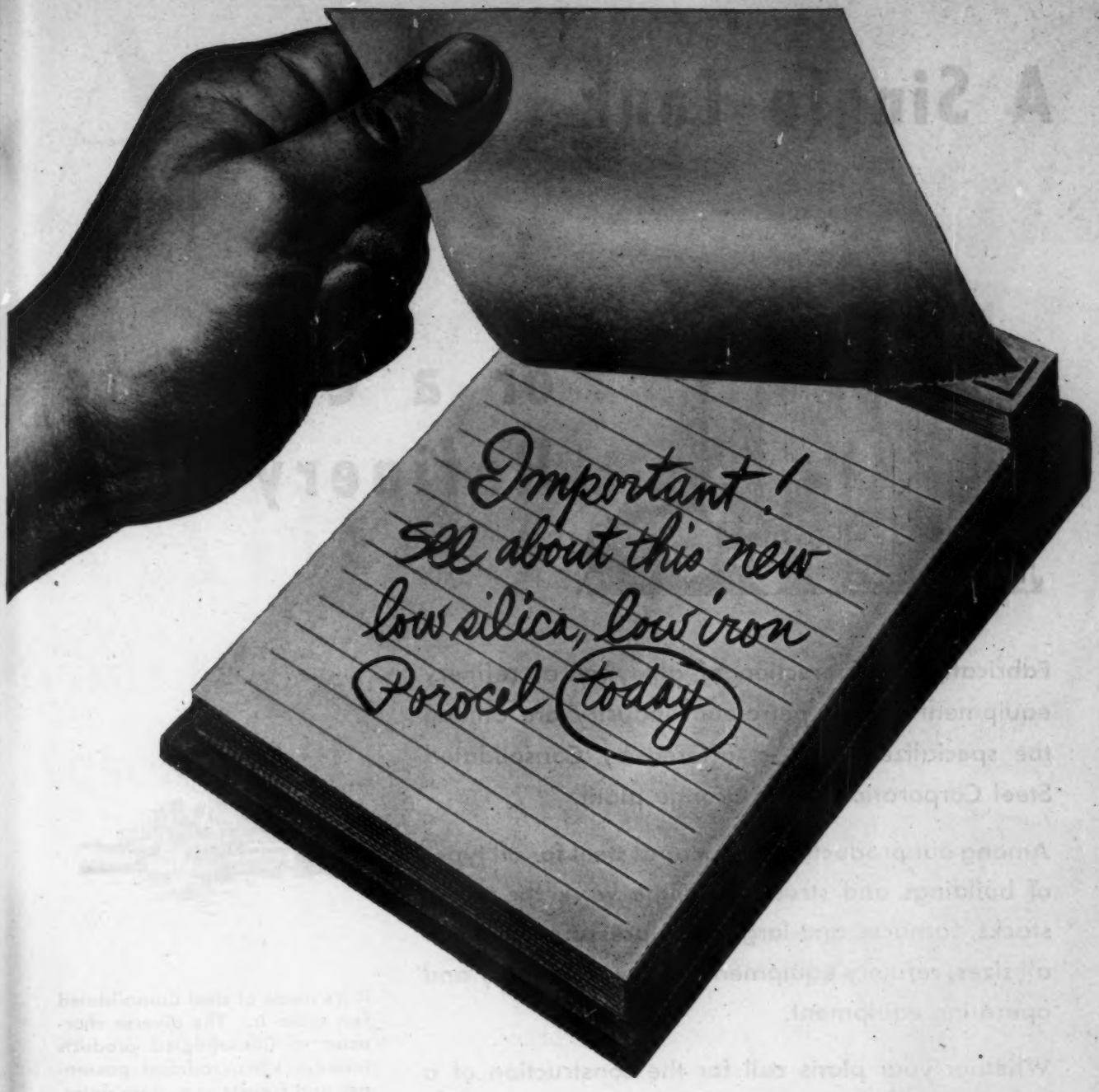
Our engineers, who have designed many special types of kettles as well as a line of standard kettles to meet special processing problems, are well qualified by experience and knowledge to help you in the design of a kettle for your heating or blending problem.



THE PATTERSON-KELLEY Company, Inc.

EAST STROUDSBURG, PA.

BOSTON 16, 96-A Huntington Avenue • NEW YORK 17, 101 Park Avenue • PHILADELPHIA 3, 1700 Walnut Street • CHICAGO 4, Railway Exchange Building



Porocel is being produced in a new grade that offers many advantages to the refiner or chemist who is looking for an adsorbent, catalyst, or catalyst carrier of high natural purity and low cost. The silica content of this new Porocel is unusually low and the iron content is at a minimum—features made possible by a special bauxite ore.

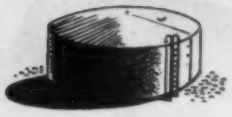
Freedom from these impurities gives the new grade twice or even three times the life of other types of Porocel when used in certain processes. As in other grades, the granules are uniform in size and hard enough to withstand many varied conditions of temperature and flow.

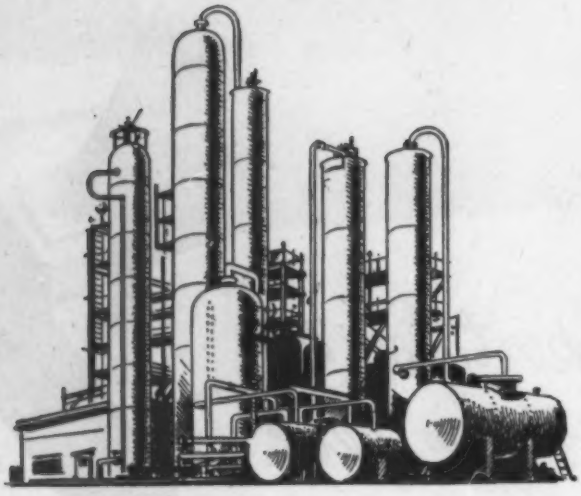
The improved performance of the new Porocel has already been proved in large commercial applications. It promises to be useful in any application where silica and iron may be troublesome. We shall be glad to send complete information. Write

ATTAPULGUS CLAY COMPANY (EXCLUSIVE SALES AGENT) • 260 SOUTH BROAD STREET, PHILADELPHIA 1, PENNSYLVANIA

POROCEL CORPORATION • BAUXITE ADSORBENTS AND CATALYSTS

A Single Tank . . .





or a Complete Refinery Unit

Fabrication and erection of all types of refinery equipment for the petroleum industry are among the specialized services offered by Consolidated Steel Corporation at its Orange plant.

Among our products are structural steel for all types of buildings and structures; plate work for tanks, stacks, furnaces and large pipe; pressure vessels of all sizes, refinery equipment; heavy machinery and operating equipment.

Whether your plans call for the construction of a single storage tank or a complete refining unit, Consolidated Steel is ready to serve you with its highly trained engineering and production staff.

If it's made of steel Consolidated can make it. The diverse character of Consolidated products includes kilns, railroad passenger and freight cars, dam gates, tugs and barges among many others. Take advantage of Consolidated's 65 years' experience in steel and let them help you with your individual problem. Write—or better—telephone, and a Consolidated man will be glad to call.

Consolidated Steel CORPORATION

ORANGE . . . TEXAS
LOS ANGELES, CALIF.

Another WELCOME RABBIT from the Research Hat!

Now, using The Union Oil Company's developments in combination with Texaco Solvent Dewaxing, refiners can:

1. Produce oil-free wax and wax-free oil simultaneously using less solvent than is ordinarily used for dewaxing the oil alone.

2. Consolidate deoiling and dewaxing into a continuous combined operation, simple and easy to control.

3. Produce regular grades of white crystalline wax without further deoiling treatment.

4. Produce high melting point microcrystalline waxes of high quality.

Licenses are now available from Texaco Development Corporation under Union Oil Company and Texaco patents.

TEXACO DEVELOPMENT CORPORATION

A Subsidiary of The Texas Company

MERIAM SIGHT FEED BUBBLERS

SHOW WHAT YOU WANT TO SEE

THESE bubblers are widely used for purging lines and for the continuous operation of tank liquid level gauges . . . also in chemical processing to show presence of any undesirable or dangerous materials in gases.

They come in two designs: ring type (Model C-1241)—illustrated—and strap type (Model C-1439). Both of these types have brass or semisteel bodies and stainless steel needle valves for bubbler control. Bowls are furnished of Pyrex glass or plastic, depending upon pressure to be handled. Bubbler bowl is easily removed in both types.

These units are sturdy and dependable, moderate in cost and good for long, trouble-free service. They fill a real need and are giving top-notch satisfaction. Ask for Bulletin 21.

THE MERIAM INSTRUMENT COMPANY
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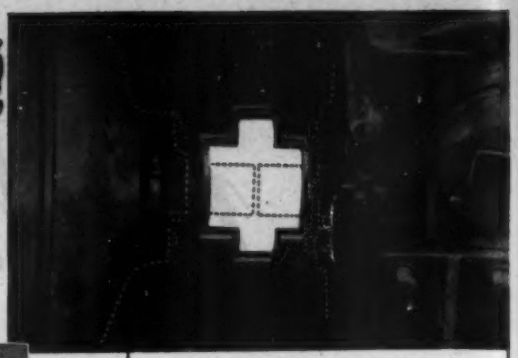
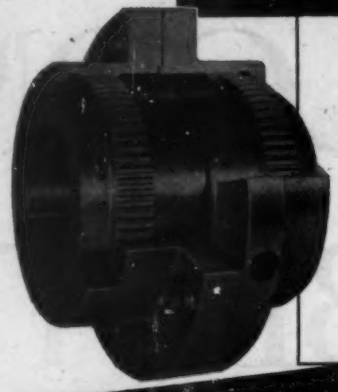
MERIAM Instruments
ESTABLISHED 1911
MANOMETERS, METERS AND GAUGES FOR THE ACCURATE MEASUREMENT OF PRESSURES, VACUUMS AND FLOWS OF LIQUIDS AND GASES

Coupling Users!





SAVE COST · SPACE *and* **SHAFT EXTENSION**

WALDRON NEW Series "A" **COUPLING**
permits use of smaller sizes by providing larger maximum bore

Waldron leads again . . . with a new design development that means greater accuracy and economies for coupling users. The new "Series A" Waldron Gear Type Coupling is designed to reduce size of coupling required for the particular shaft, reduce shaft extension for greater accuracy in operation, save space—and money.

It embodies all the famous Waldron design refinements: all forged steel, made to close manufacturing tolerances with positive dust proof and oil tight seal. Identical externally geared hubs key to shafts, enclosed by two piece cover sleeve that functions as a single rigid unit.

Ask us to send you specific advanced information on this new "Series A" Waldron Coupling that will easily prove most accurate and economical to buy and use.

Made in Standard, Mill Motor, Heavy Duty, Floating Shaft, Cut-Out, Sheer Pin, Spacer Sleeve, Jordan, Vertical Floating Shaft and Rigid Types.

COUPLING DIVISION

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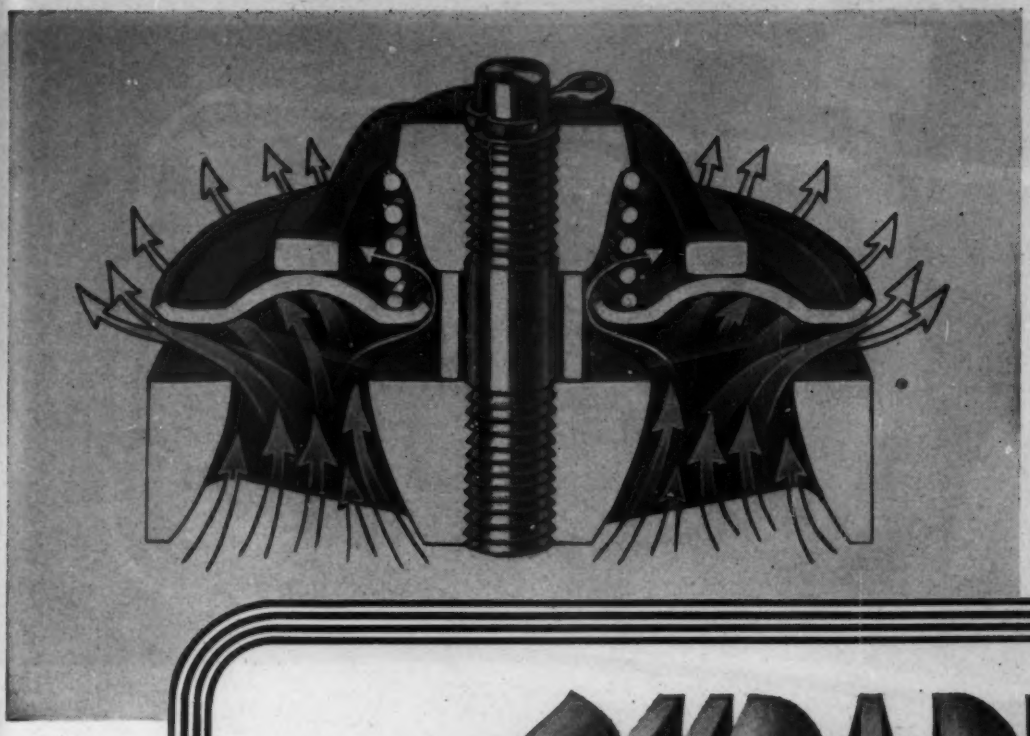
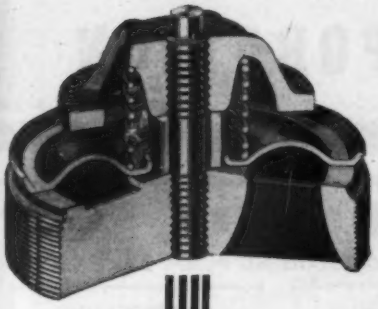
Main Office and Works
New Brunswick, New Jersey
COUPLINGS



No reciprocating pump is more efficient than its valves and valve performance is dependent on the method utilized to close the valves.



DURABLA

VALVE UNITS UTILIZE PROTECTED, SELF-CLEANING, LONG LIFE SPRINGS

DURABLA Valve Units* utilize springs to return the valve member to the seat. DURABLA design completely eliminates the usual objections to the use of springs. This permits substantial reduction in weight; more compact installation; and greater flexibility in location of the valve service. Non-spring-actuated valves and other types of spring-actuated valves do not offer these advantages.

1. **The DURABLA Valve Spring is normally never compressed more than 50% of its length due to the protection of the spring guard. The coils of the spring never touch when the spring is in compressed position.**
2. **The DURABLA Valve Spring is self-cleaning as by virtue of the open type spring guard it is exposed to the fluid flow.**
3. **DURABLA Valve Springs operate effectively at 3000 rpm (6000 motions of the valve per minute) and higher.**
4. **The protection of the DURABLA Valve Spring permits lighter spring pressure, thereby reducing energy required to open the valves.**

DURABLA Protected Self Cleaning Valve Springs are just one of the characteristics of DURABLA Valve Units which are an implicit guarantee of high efficiency, long life and long term economy.

Address DURABLA Engineering Department
for Information and Bulletin; Reference 9R12

*Patent Numbers 2090486, 2117504

DURABLA MANUFACTURING COMPANY
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NATURAL GASOLINE, OIL REFINERY
CHEMICAL PLANT
LIGHT and HEAVY PLATE PRESSURE VESSELS

Specialized experience of over 30 years in the building of Pressure Vessels for Natural Gasoline Plants, Refineries and Chemical Plants, in addition to supplying equipment to rigid war requirements, place VULCAN in the foreground for Leadership in Quality, Workmanship and Maximum Ultimate Service for post war requirements.

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PLANT: North Harvard & Frisco R.R. TULSA, OKLAHOMA Telephone 5-2101

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ESTABLISHED 1869

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PUMPS

BUILDERS OF OUTSTANDING PUMPS SINCE 1869

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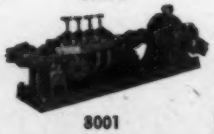

8001

RECIPROCATING

942

3918

2446

2352L

3833

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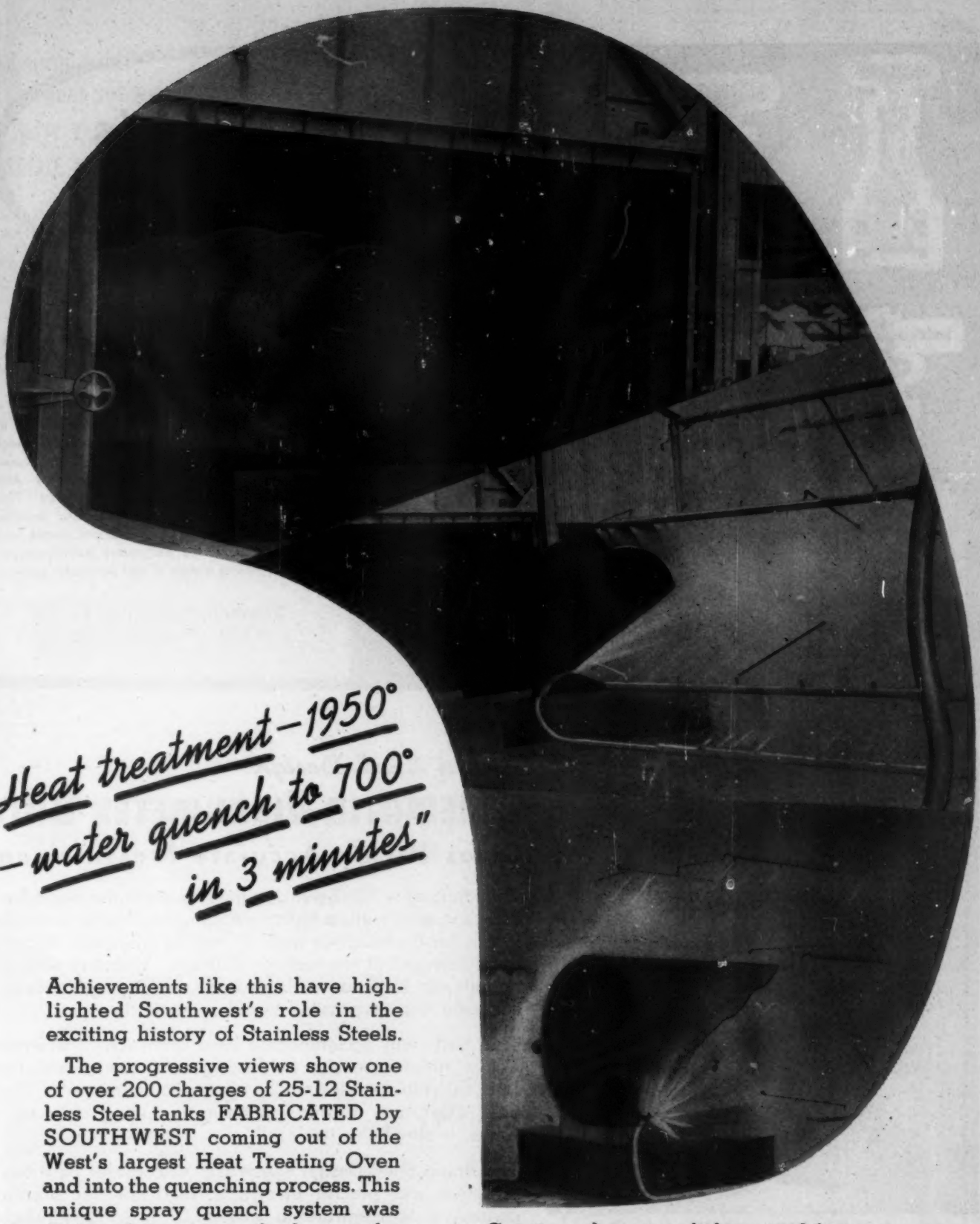


"Heat treatment—1950°
—water quench to 700°
in 3 minutes"

Achievements like this have highlighted Southwest's role in the exciting history of Stainless Steels.

The progressive views show one of over 200 charges of 25-12 Stainless Steel tanks FABRICATED by SOUTHWEST coming out of the West's largest Heat Treating Oven and into the quenching process. This unique spray quench system was designed to remove the heat at the rate of 1,000,000 BTU per MINUTE from vessels weighing 11,000 lbs., NINE feet in diameter.

Continued accomplishments like this reflect why "Built By Southwest" is synonymous with sound engineering and skilled craftsmanship.

Southwest Welding & Manufacturing Co.

Alhambra, California

The Oil Engineer's Choice

NH VALVES

for the oil industry cover a wide range of specialized productions. Gate, Stop and Check Valves for high pressures and temperatures, steam oil, gas and for general purposes. Also Newman-Milliken Glandless Lubricated Plug Valves for all oilfeld and refinery services. Working pressures to 5,000 lbs. per square inch (tested to 10,000 lbs. per square inch Kerosene). Made in various metals to suit particular services.

Newman, Hender & Co. Ltd

WOODCHESTER NH GLOS. ENGLAND

Braun Shell-Design Kinematic Viscometer Bath

Braun Shell-Design

KINEMATIC VISCOMETER BATH

Gives Highly Accurate Measurement

This apparatus has been designed to meet the need for a constant temperature bath, operating to closely controlled limits, for the exacting work of making kinematic viscosity measurements of the highest accuracy. Viscosity determinations can be made with greater speed, convenience and accuracy than is possible by other methods.

This bath will accommodate nine Zeitfuchs Viscometer Tubes simultaneously, permitting continuous operation. It is suitable for kinematic viscosity measurements of all oils. Operation of the apparatus, including cleaning of tubes, is simplicity itself.

The Braun Shell-Design Kinematic Viscometer Bath has a sensitive and precise electronic regulator for absolute control of temperature to within 015° F. Continuously variable settings can be made at any point between room temperature and 240° F.

WRITE FOR BULLETIN

BULLETIN C-144 GIVES COMPLETE DESCRIPTIVE DETAILS. ADDRESS DEPT. P-12 FOR YOUR COPY.

BRAUN CORPORATION

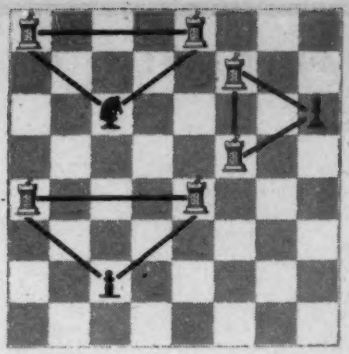
2260 EAST 15TH ST. LOS ANGELES, CALIF.

Braun-Knecht-Heimann Co. San Francisco, California

BRAUN

Scientific Supplies Co. Seattle, Washington

An impossible chess set-up...



BUT MIGHTY USEFUL FORMULAS

Metal Peroxides by Becco are insoluble in water but soluble in mineral acids. They are compatible with many inorganic and organic materials and can be used in the preparation of tooth powders, in processing of foodstuffs, and, in general, where oxidation at high temperatures is required. Some of these peroxides also find use as chemo-therapeutical agents and for cosmetic and pharmaceutical preparations.

ACTIVE OXYGEN IS ON ACTIVE DUTY

OTHER BECCO PRODUCTS:

Electrolytic Hydrogen Peroxide —100 vol. (27.5% by weight)
Ammonium Persulfate
Potassium Persulfate
Pyrophosphate Peroxide*
Sodium Carbonate Peroxide*
Acetyl Peroxide*
Urea Peroxide
**Available in research quantities only at present.*

BECCO MAGNESIUM PEROXIDE—50%
White Powder.
Contains 14.2% active oxygen.
Exceedingly stable even at temperatures above 100° C.

BECCO CALCIUM PEROXIDE—60%
Yellowish Powder.
Contains 13.6% active oxygen.
Has outstanding stability even above 100° C.

BECCO ZINC PEROXIDE—45%
White Powder.
Contains 7.4% active oxygen.
Extremely stable even above 100° C.

The available supply of all three of these Metal Peroxides is limited at present.

BUFFALO ELECTRO-CHEMICAL CO., Inc.
BECCO SALES CORPORATION
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JUST PUBLISHED!

Catalytic Chemistry

By HENRY W. LOHSE

Consulting Chemist, Fellow of the Royal Society of Arts, London; Canadian Institute of Chemistry; American Chemical Society; American Assn. for Advancement of Science.

CONTENTS

Chapter I. Brief History of Catalytic Chemistry
Chapter II. Catalytic Theory
Chapter III. Nature and Properties of Catalysts
Chapter IV. Specific Types of Catalytic Reactions
Chapter V. Industrial Catalytic Reactions

This book aims at a factual presentation of the underlying principles of catalytic phenomena and the application of catalytic reactions in industrial processes.

Particular attention has been paid to the presence of impurities in catalytic reaction systems, and to the role of traces of other metals in silver, copper, iron, nickel, etc., used as catalysts.

A separate section has been devoted to each of the various types of catalytic reactions. The nature and properties of catalysts, specific types of catalytic reactions, as well as industrial catalytic reactions have been discussed in detail.

Many clear illustrations will help in the understanding of little understood phenomena.

471 pages fully illustrated $8.50

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New Efficiency-Balanced

RIDGID PIPE CUTTER

gives you faster, easier, cleaner pipe cutting

RIDGID *Tubing Cutter with rolls —quick cutting of any tubing or thin-wall conduit.*

● You like the feel of it—the neatly balanced design of the rugged new style malleable frame tells your practiced hand that it's going to cut pipe with easy speed. And it does—the thin tool-steel blade wheel always cuts true, fast, almost without burr. Every cutter is carefully factory tested before shipment. Five sizes to 6," two 4-wheel cutters to 4." For pipe cutting with least effort—ask your Supply House for the new, efficient RIDGID Cutter.

RIDGID
WORK-SAVER PIPE TOOLS
THE RIDGE TOOL COMPANY • ELYRIA, OHIO, U. S. A.

•AMERICAN QUALITY PARADES THE HIGHWAYS•

A REAL ALLY OF THE PETROLEUM TRANSPORTER

This advertisement illustrates a really great gasoline transport trailer—not only soundly engineered but sturdy in construction.

This equipment carries all the approved safety features and bear in mind the frame and tank are an integral unit in order to properly equalize and distribute the constant shifting load and thus reduce vibration to a minimum. The two-step spring suspension is designed to give a smooth easy ride when the unit is empty.

AMERICAN BODY & TRAILER COMPANY

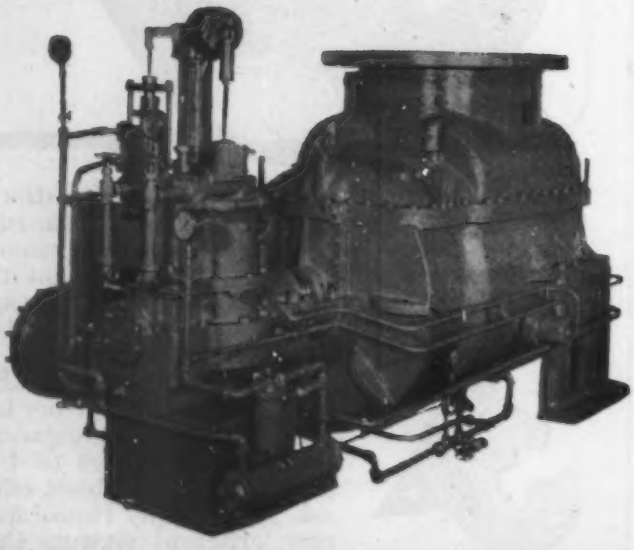
AMARILLO, TEXAS
307 Philmore Street

MAIN OFFICE—OKLAHOMA CITY
1500 Exchange Avenue

LITTLE ROCK, ARK.
400 Center Street

MURRAY

LOW PRESSURE CONDENSING TURBINES



Are you wasting low pressure steam to atmosphere? Why not install a low pressure condensing turbine similar to the unit shown which drives a centrifugal refrigeration compressor. The turbine shown delivers 485 horsepower at 3600 RPM on steam at 2 pounds initial pressure, exhausting to 26 inches vacuum, is equipped with oil relay type variable speed governor, full force feed lubrication, vacuum breaker, vertical upward exhaust opening.

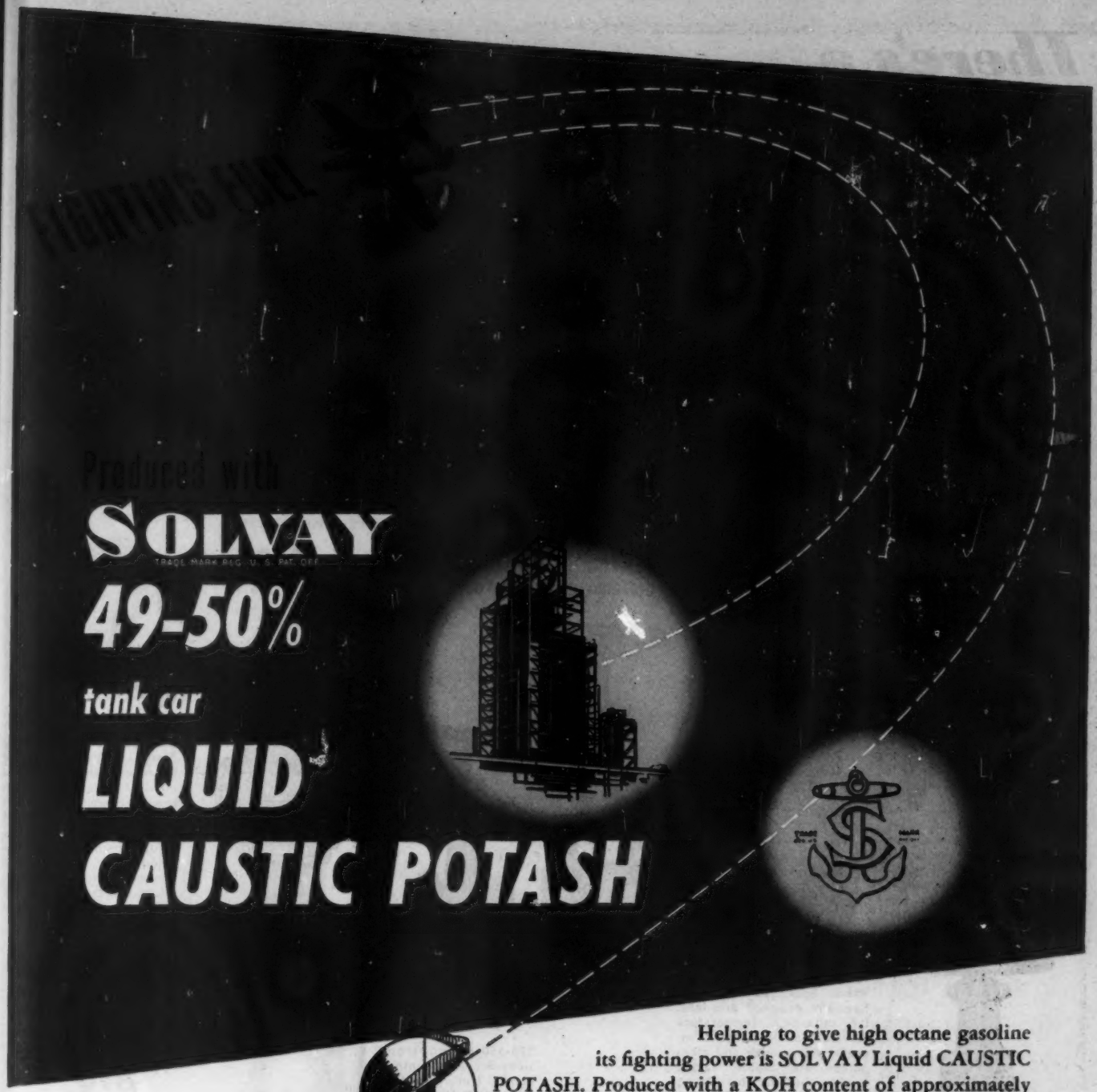
For all variations of steam turbines up to and including 2500 KW, refer to the MURRAY sales representative nearest you.

Sales Offices in all principal cities

MURRAY IRON WORKS COMPANY

BURLINGTON, IOWA

BUILDERS OF STEAM POWER EQUIPMENT FOR THREE QUARTERS OF A CENTURY



Helping to give high octane gasoline its fighting power is SOLVAY Liquid CAUSTIC POTASH. Produced with a KOH content of approximately 50%, it meets the needs of refiners for a high quality alkali with an *absolute minimum of impurities*. Prompt shipments in tank cars from our Syracuse plant.

Solvay can meet your requirements . . . Write today!

LIQUOR

SOLID

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There's a POWELL VALVE for every Refinery Service

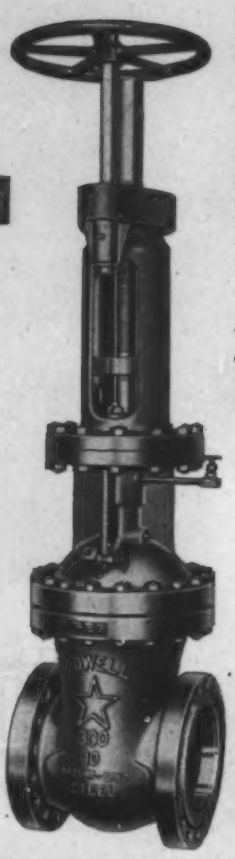
Keeping pace with and even anticipating the amazing progress of the oil refining industry, Powell Engineering has developed a complete line of valves to satisfy the requirements of every flow control service in the refinery of today.

In addition to bronze and iron valves of every necessary type and pressure and all types of steel valves for pressures from 150 to 2500 pounds and temperatures up to 1400 F., Powell Engineers have made a notable contribution to the industry by designing many special valves to solve the problems imposed by new processes and products. A few examples are shown here.

The Wm. Powell Co., Cincinnati 22, Ohio

DISTRIBUTORS AND STOCKS IN ALL PRINCIPAL CITIES

Class 300-pound, 16" Cast Steel Gate Valve designed especially for producing 100 octane aviation gasoline. Has automatic steam sealing mechanism and top mounted electric motor operator.



Class 300-pound, 10" Cast Alloy Steel O. S. & Y. Gate Valve. Spur gear operated. Specially designed and built for ultra-high temperature service. Double wedge discs, seats, disc guides and stem guides are Stellite faced. Cooling fins for dissipating heat and thereby lowering the temperature in the stuffing box are another feature.

200-pound Bronze Gate Valve with renewable disc.

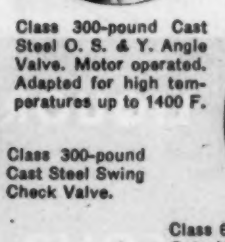
125-150-pound Iron Body Bronze Mounted or All Iron "Master Pilot" Gate Valve.

Class 300-pound Cast Alloy Steel Gate Valve, designed to meet special requirements and to handle high temperatures. It has 12" port size venturied to 20" size end flanges to accommodate insulated pipe. Provided with top-mounted, enclosed, explosion proof, electric motor operator for quick, positive opening and closing.

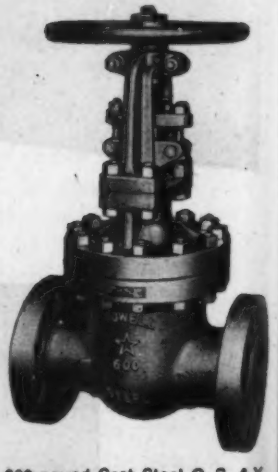
125-pound Iron Body Bronze Mounted or All Iron O. S. & Y. Gate Valve.

150-pound Stainless Steel O. S. & Y. "Y" Valve.

Class 300-pound Cast Steel Swing Check Valve.



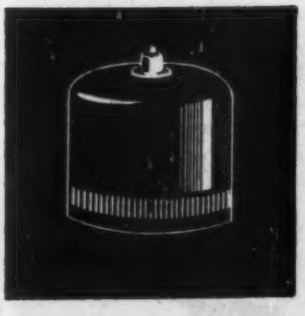
Class 300-pound Cast Steel O. S. & Y. Angle Valve. Motor operated. Adapted for high temperatures up to 1400 F.



Class 600-pound Cast Steel O. S. & Y. Gate Valve. Powell Cast Steel Valves are available in all pressure classes from 150 to 2500 pounds, inclusive.

POWELL VALVES

P. S. LIGHTWEIGHT BUBBLE CAPS



So Many New Refineries Can't Be Wrong!

So many new refineries wouldn't specify P. S. (for Pressed Steel) Bubble Caps unless substantial savings could be made in construction and ultimate operation. New erection costs are reduced by their lightweight alloy construction which permits lower freight and handling charges and the design of lighter weight trays. All P. S. Bubble Caps are heat treated **after** fabrication. This safeguard, together with the development and use of special corrosion resisting alloys, are factors that provide long life, less trouble from coking and other causes of frequent replacement and production delays.

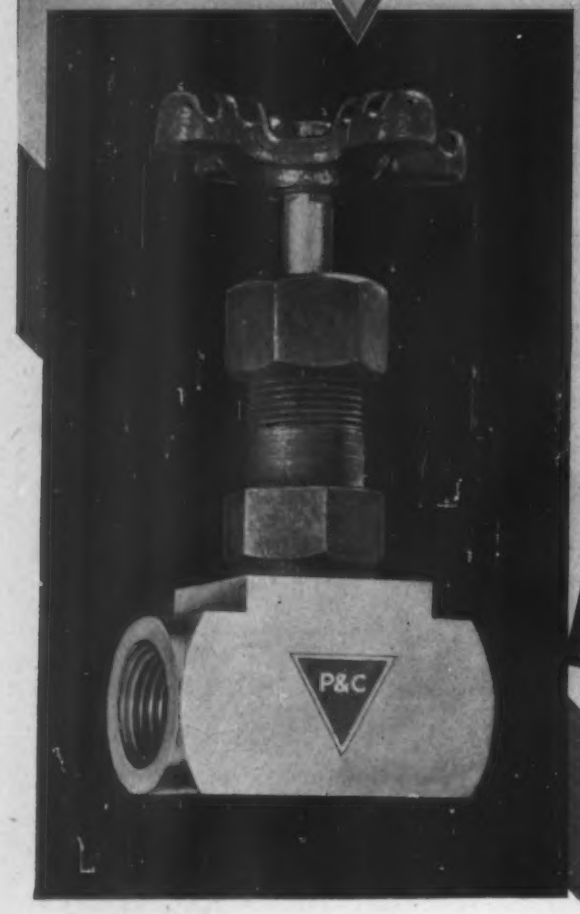
Send us your blueprints. We can quote on any type of Bubble Cap, Sectional Tray, Riser or Welded Alloy Tubing.

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

BRANCH OFFICES: 312 Curtis Bldg., Detroit; 503 Nicholas Bldg., Toledo; 1915 Engineers Bldg., Chicago; 51 E. 42nd St., New York; 1005 Sterling Bldg., Houston, Texas; A & M Accessories Ltd., 19 Melinda St., Toronto, Canada; Broad St. Station Bldg., Philadelphia; 417 So. Hill St., Los Angeles.

PRESSED STEEL COMPANY PRODUCTS: Carburizing and Annealing Boxes, Thermocouple Protection Tubes, Seamless Steel Cylinder Caps, Seamless Steel Neck Rings, Welded Alloy Tubing for High Temperature and Corrosive Applications, Radient Tubes, Inner Covers and Base Sheaths for Steel Mills

A *Tough* LITTLE VALVE OF ALL WORK



• This line of "bar stock" valves was developed by R-P&C as rugged, economical, close control valves. But experience in service quickly demonstrated their usefulness practically anywhere that a small, tough valve is needed for either close control, normal regulation or shut-off. Their service, pressure and temperature ratings extend over a wide range.

R-P&C bar stock valves are in stock in globe and angle types, made of bronze, carbon steel, 12-14% stainless steel, combination carbon steel and 12-14% stainless steel and in 18 and 8 stainless steel—in sizes up to 1".

Let us give you complete information about R-P&C bar stock valves. It is contained in a file size booklet—DH-1186. We will be glad to send you a copy.

BOOKLET DH-1186

R-P&C offers you a single responsible source for bronze, iron and steel gate, globe, angle and check valves—cocks and Lubrotite gate valves—bar stock valves —cast steel fittings—D'Este Automatic Regulating Valves.

READING-PRATT & CADY

MANUFACTURERS OF
READING CAST STEEL VALVES AND FITTINGS • PRATT & CADY BRASS AND IRON VALVES
D'ESTE AUTOMATIC REGULATING VALVES

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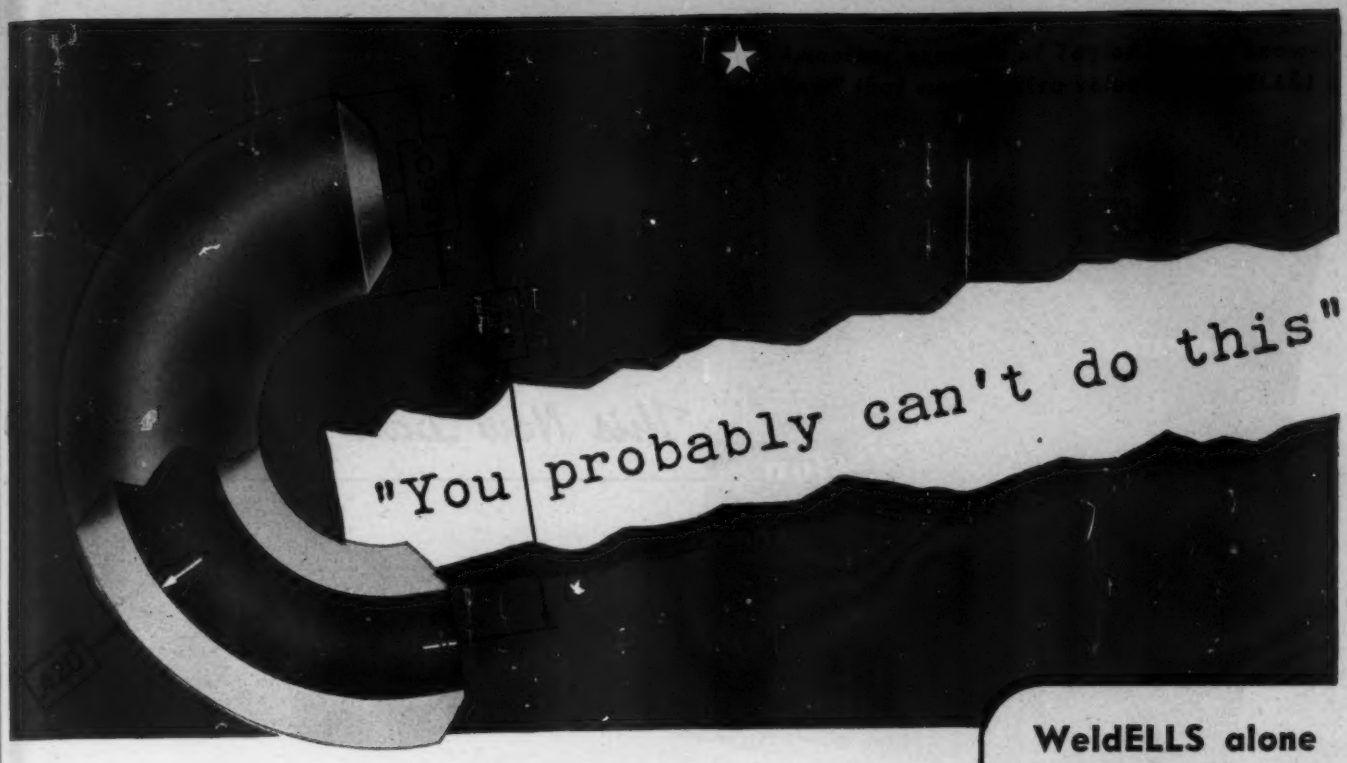
READING-PRATT & CADY DIVISION
AMERICAN CHAIN & CABLE

TRADE MARK



....but we did!

★ *That, in effect, is what people occasionally have said when putting some tough specification before us . . . but if they were trying to stump someone they came to the wrong place!*

The fitting pictured above is a good example of this. As far as we know, no one else ever tried to forge a welding elbow or return bend having such great wall thickness in relation to the size of the fitting. There was good reason to doubt if it could be made, because such fittings simply couldn't be formed by the processes ordinarily employed in making welding fittings.

But special methods, developed by Taylor Forge, made this easy for us. It was another example of "You say it can't be done—but here it is!"

IN our standard, stock line of welding fittings, as in this special heavy wall return bend, you also find a combination of features that could not be achieved by the processes ordinarily employed in making welding fittings.

Take the selective reinforcement of the zone of highest stress in WeldELLS, for instance . . . or the tangents which help so much in lining up and welding . . . or the final truing operation which gives those extremely accurate dimensions.

These are features which eloquently attest to the "know-how" of Taylor Forge acquired in more than 40 years of handling just about every conceivable kind of forging problem in the piping field. Read the entire list of features opposite and we believe you will agree that

WeldELLS have everything

WeldELLS alone combine these features:

Seamless — greater strength and uniformity.

• **Tangents**—keep weld away from zone of highest stress—simplify lining up.

• **Precision quarter-marked ends**—simplify layout and help insure accuracy.

• **Selective reinforcement** — provides uniform strength.

• **Permanent and complete identification marking**—saves time and eliminates errors in shop and field.

• **Wall thickness never less than specification minimum**—assures full strength and long life.

• **Machine tool beveled ends**—provides best welding surface and accurate bevel and land.

• **The most complete line of Welding Fittings and Forged Steel Flanges in the World** — insures complete service and undivided responsibility.

TAYLOR FORGE & PIPE WORKS, General Offices & Works: Chicago P.O. Box 485
New York Office: 50 Church Street • Philadelphia Office: Broad Street Station Bldg.

This New Data Book No. 1000

Contains Complete Information On

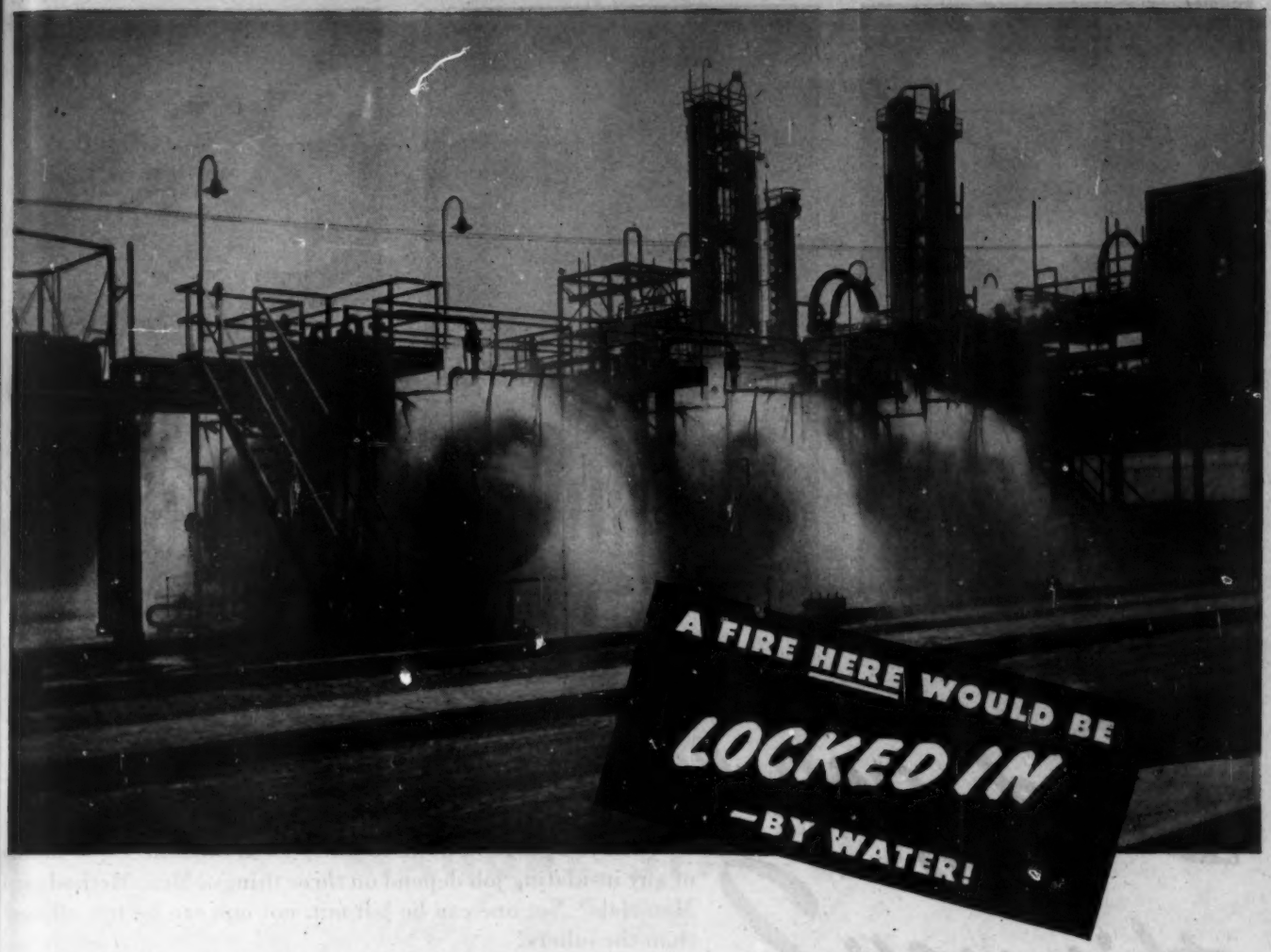
Republic Pneumatic Transmitters

OPERATING ON THE FORCE-BALANCE PRINCIPLE

for the measurement
and control of
FLOW
PRESSURE
LIQUID LEVEL
LIQUID DENSITY
DIFFERENTIAL VAPOR PRESSURE

A Copy of This 28 Page Data Book Will Be Mailed On Request

REPUBLIC FLOW METERS CORPORATION
2240 DIVERSEY PARKWAY • CHICAGO 47, ILLINOIS



Those tanks contain isobutane. Yet any fire starting in and around those tanks would be put under control almost immediately . . . *using water to do it!*

This plant, like many others where inflammable liquids are handled, puts its reliance on water (hitherto not considered effective on oil fires), because it has learned that water *in WaterFOG form* is the safest, surest protection.

Should a fire break out, those tanks, as shown above, would instantly be covered by clouds of WaterFOG — tiny water particles much finer than spray, with tremendous heat-absorptive power. Enveloping the area, cooling the blaze, shutting off oxygen, the WaterFOG would quickly confine and control the fire until it burned out or the supply of isobutane was shut off.

FIGHTS MANY TYPES OF FIRES

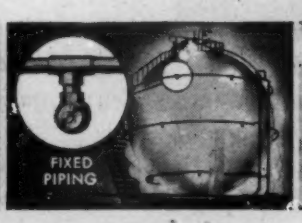
Rockwood-engineered systems of fixed piping are today protecting many types of equipment, processes and structures — transformers, paint shops, quench tanks, engine test cells. Portable WaterFOG equipment — nozzles and applicators to be attached to regular fire hose lines — is also available.

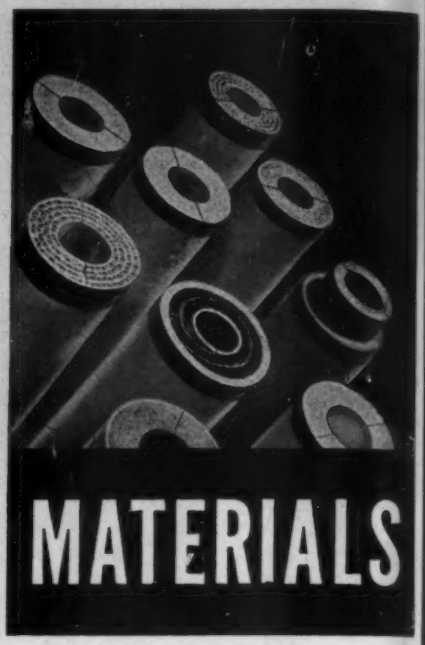
Rockwood WaterFOG is approved by Underwriters' Laboratories and Associated Factory Mutuals. Write for Bulletin 123. Business executives can arrange to have showings of colored movies (16 mm.) of Rockwood WaterFOG in action. Write:

ROCKWOOD SPRINKLER COMPANY
82 Harlow Street, Worcester 5, Mass.
Specialists in Fire Protection Engineering, Equipment and Installation since 1907

Water Engineered by Rockwood Cools. Confines. Smothers Oil Fires

ROCKWOOD WaterFOG





Did you ever look at it this way?

• When you get right down to *facts*, doesn't the success or failure of any insulating job depend on *three* things—Men, Methods and Materials? Not one can be left out, not one can be less efficient than the others!

Ruberoid's complete service gives you every element for success—not just one, but the whole three! *Men* trained and experienced in doing first-class work, *Methods* developed through years of research and practical application, plus a complete line of *Materials* whose performance is outstanding under all conditions.

No gaps in the Ruberoid system. It's the *sure* way to successful insulating. A Ruberoid engineer will be glad to give you every help and assistance . . . *without obligation.*

Write for Ruberoid Insulation Guide and technical data.

The RUBEROID Co., *Executive Offices*, 500 Fifth Avenue, New York 18, N. Y.

ASPHALT AND ASBESTOS BUILDING MATERIALS

MEN...who know how, not just workmen, they're technicians who know insulating problems and know how to solve them! Ruberoid Approved Applicators are located in the principal industrial centers throughout the U.S.A.

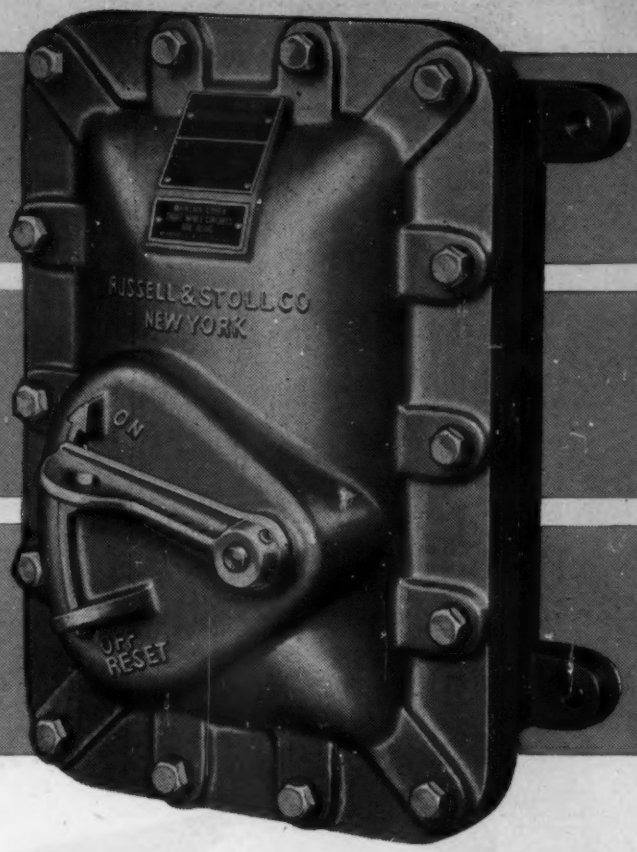
METHODS... developed through a broad knowledge and experience with difficult insulating jobs, kept constantly abreast of the latest developments through extensive research.

MATERIALS...specifically designed to meet any temperature range and condition right up to 1900° F. The right insulation for your needs is contained in Ruberoid's *complete* line of materials.

Heavy wall castings. High quality rust-inhibiting finish.

Simplified operation. No loose parts.

Substantial wiring space to facilitate connections.



External lugs for mounting. Provision for numerous conduit connectors.

Provision for padlocking.

Standardized designs permit perfect interchangeability.

MANUAL STARTER

Explosion-proof, water-tight, dust-tight

LIGHTING FIXTURES

JUNCTION BOXES

RECEPTACLES AND PLUGS

Since 1902

The manual starter shown above is ruggedly designed and built to withstand unusually severe service. Particular attention has been given to corrosion resistance, ease of installation and low maintenance.

Over the years R & S has pioneered in the development and standardization of precision-built control equipment in keeping with industries' expanding requirements of new processes and codes.

A large variety of standardized explosion-proof enclosures is available for grouping and assembly of control and power units in panel form, at minimum cost and without the usual delay of special designs.

R & S Standard Enclosures have wall sections permitting a great variety of conduit arrangements and sizes to suit job requirements. This simplifies material lists and reduces inventories caused by field changes.

Here are a few of the recent items designed especially for hazardous locations.

- HEAVY DUTY PUSH BUTTONS
- RELAY ENCLOSURES
- EQUIPMENT ASSEMBLIES
- PANEL BOARD MOUNTINGS
- PILOT LIGHTS
- COMBINATION CIRCUIT BREAKERS AND STARTERS UP TO 50 H.P.

RUSSELL & STOLL COMPANY

EXPLOSION-PROOF WATER-TIGHT AND EVER-LOK RECEPTACLES, PLUGS, CONNECTORS, SWITCHES AND FIXTURES

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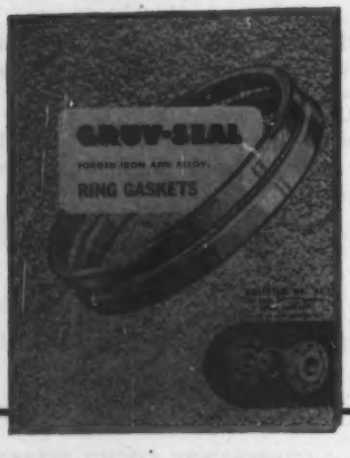
G

REDUCE UNPREDICTABLE PIPE LINE EMERGENCIES

on High Pressure, High Temperature Pipe Lines with...

Gruv-Seal, Forged Iron and Alloy, Ring Gaskets



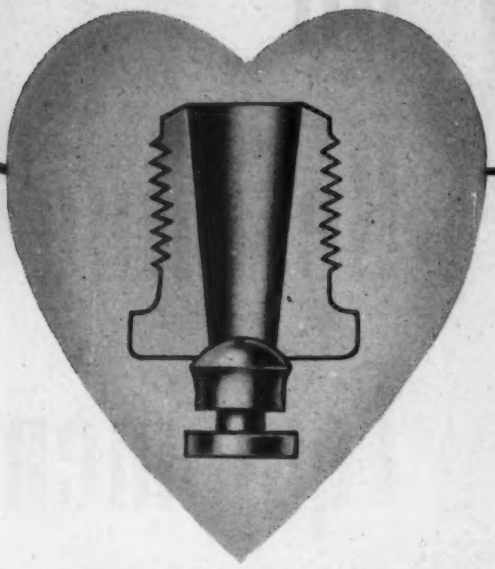
Forestall pipe line trouble . . . with pressure-proof joints, tight as a weld, made with Gruv-Seal, Forged Iron and Alloy, Ring Gaskets. Wrench pressure molds metal into grooves—makes a tight seal that stays tight, always—reduces pressure losses and other pipe line trouble. Gruv-Seal, Forged Iron and Alloy, Ring Gaskets are machined to a fine smooth finish and fit grooves perfectly. These gaskets should be used at all flange connections, valve bonnet joints, and at joints where disassembly is a necessary requirement. Available in several different grades of metal for different services. Specify valves and flanges grooved for Gruv-Seal Ring Gaskets—for tight, trouble proof joints. Manufactured by a special forging method which eliminates metal porosity and interlocks the metal fibre lines into a dense, tough structure, Gruv-Seal, Forged Iron and Alloy, Ring Gaskets are exact in every detail, true in diameter, circumference, and in thickness. They are one item of a complete line of Diamond "S" Forged Boiler and Tank Accessories which include manhole cover assemblies, handhole cover assemblies, special welding street ells, and other similar devices, all forged to close tolerances from suitable metals. They fully meet and exceed A.S.M.E. requirements for steel use in pressure vessel parts. Write for Catalog No. 10 on Diamond "S" Boiler and Tank Accessories.

Gruv-Seal Ring Gasket Bulletin 45 contains complete description, and illustrations showing applications, of Gruv-Seal Ring Gaskets (Type O), Oval, and (Type X), Octagon; also descriptions of different grades of metal of which these rings are forged for different services. Bulletin includes complete list of standard sizes and basic dimensions for API and ASA ring numbers and information on additional sizes for other services; also list prices and other useful data. Write for your copy now.

THE STEEL IMPROVEMENT & FORGE CO.
976 East 64th Street CLEVELAND, OHIO

New HI-CAP Orifice Gives STRONG Traps

UP TO 25% *greater* CAPACITY



THE heart of the improved STRONG Trap is this HI-CAP* Valve and Seat assembly. New, scientifically designed orifice throat gives up to 25% greater capacity, avoids turbulence and minimizes choking caused by flash steam. *An important part of STRONG service is continued attention to parts for traps in service. HI-CAP parts are available for your present 70 series traps.*

*HI-CAP—Registered trade mark

STRONG 2-IN-1 TRAPS

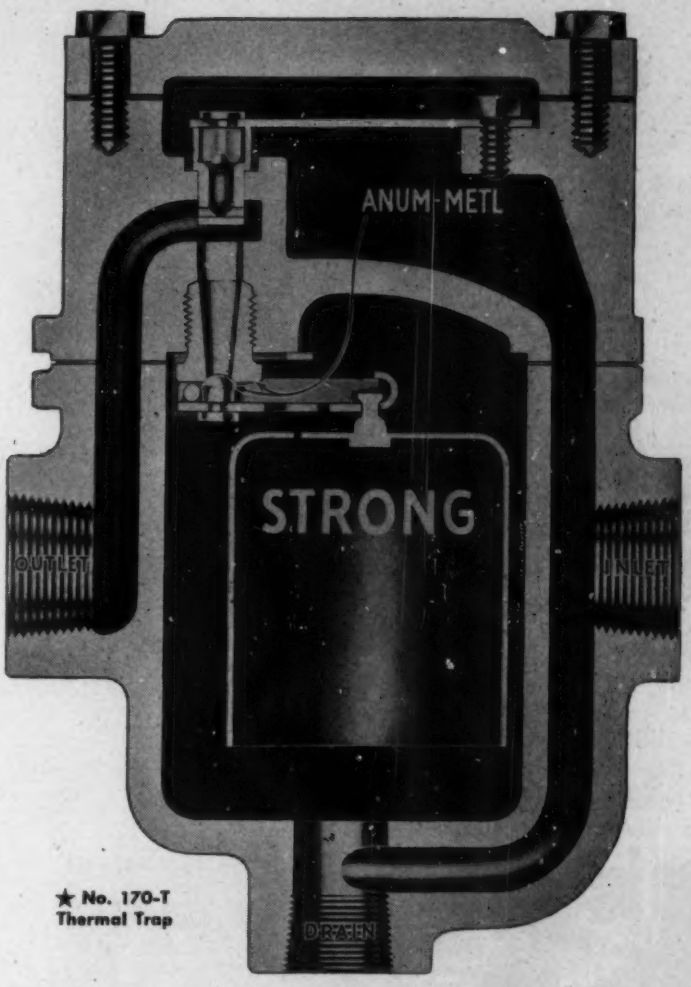
THE STRONG "T" Traps combine in one unit the economies of inverted bucket traps with air removal capacity of the thermal traps. They are particularly suited to equipment or processes requiring quick air and condensate removal for rapid heating up.

The "T" type is included in the new line of HI-CAP straight-through traps in sizes from 1/2" to 1-1/4". With the new STRONG HI-CAP Traps . . . both standard and thermal . . . you get:

- HI-CAP orifice
- Screwed in ANUM-METL valve and seat
- Straight-through or elbow piping
- All stainless steel trim

Write for New Bulletin on HI-CAP Traps

STRONG, CARLISLE & HAMMOND CO.
Over 40 Years of Steam Specialties
CLEVELAND 13, OHIO



★ No. 170-T
Thermal Trap

NEW lever design gives quick, full opening without dribbling.

NEW renewable seat permits easy servicing.

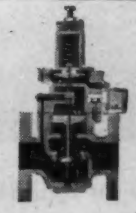
NEW inlet-outlet location places trap below inlet pipe at all times.

REG TRADE MARK

OTHER ANUM-METL Reg. Trade Mark

STRONG

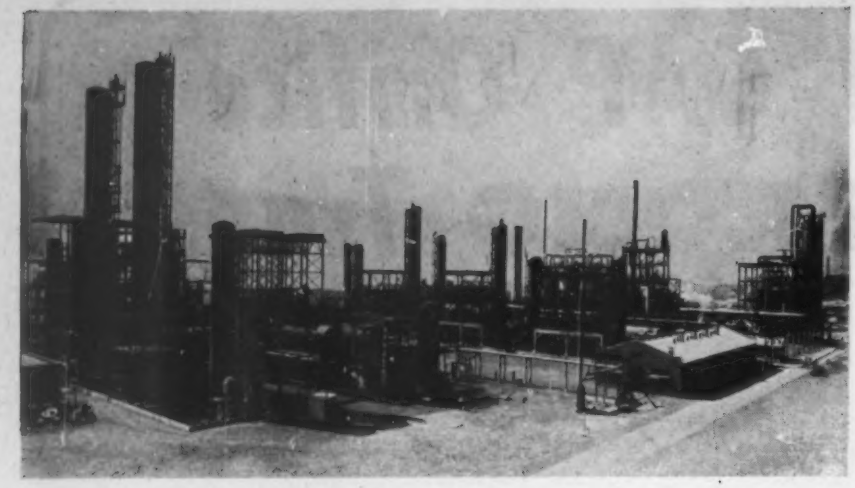
STEAM SPECIALTIES



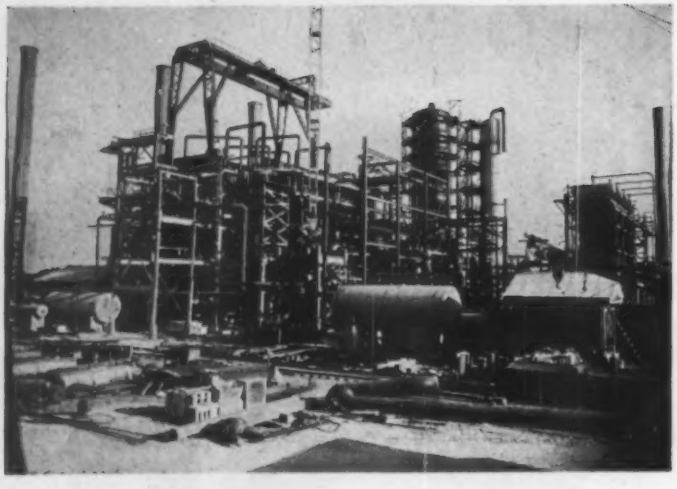
Reducing Valves

No. 80—Series Trap

HI-CAP Inverted Bucket Traps



Oil Refining Equipment



The Principal Pressure Vessels, Steel Plate Work and Special Equipment for these plants and many more were made in our plant at Chester, Pennsylvania.

Launching an 18 Foot Tower—Too Large for Rail Shipment—Was Shipped to Distant Refinery by Water.

Sun Shipbuilding and Dry Dock Co.

Chester, Pa.

Enduro Pays in many ways

High strength and long life—inherent characteristics of Republic ENDURO Stainless Steel can bring you profitable savings in equipment maintenance and replacement expense.

ENDURO is resistant to abrasion and rough use . . . tough enough to stand up under punishment. Its strength-to-weight ratio is among the highest of all metals. And because it is highly resistant to heat, ENDURO loses little of its strength when used in high temperature applications.

There are many other profitable reasons, too, why it pays to use ENDURO Stainless Steel—for still and tower linings, bubble trays and caps, heat exchanger and condenser tubes, hot oil lines and pumps, and valves and valve seats.

For complete information, write *today* to:

REPUBLIC STEEL CORPORATION
Alloy Steel Division • Massillon, Ohio
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ENDURO STAINLESS STEEL
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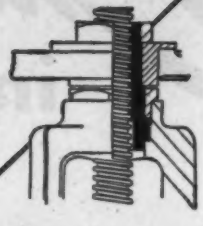
6 BIG REASONS WHY

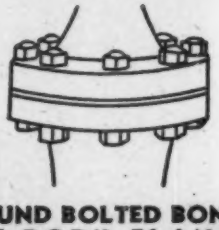
150 AND 300 POUND
INTEGRAL FLANGED

Vogt
Drop Forged
Steel
GATE VALVES
ARE
PREFERRED!

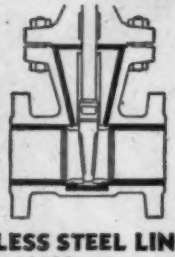
KNOBBED MALLEABLE IRON HANDWHEEL
Gives a firm, non-slip grip. Sturdily built for long use.



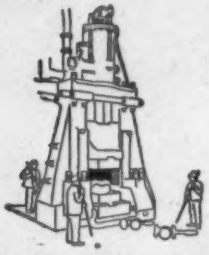
REMOVABLE YOKE NUT
For quick and easy servicing without dismantling the bonnet.



ROUND BOLTED BONNET and BODY FLANGES
Minimizes distortion under pressure. Eliminates special gasket.



STAINLESS STEEL LININGS
Recommended for severe erosion-corrosion conditions. Furnished on special order.



DROP FORGED STEEL BODY and BONNET
Drop Forging refines the grain structure and imparts extra toughness and endurance.

ROLLED-IN SEAT RINGS
No threads to corrode or leak.
No lugs to impede the flow.

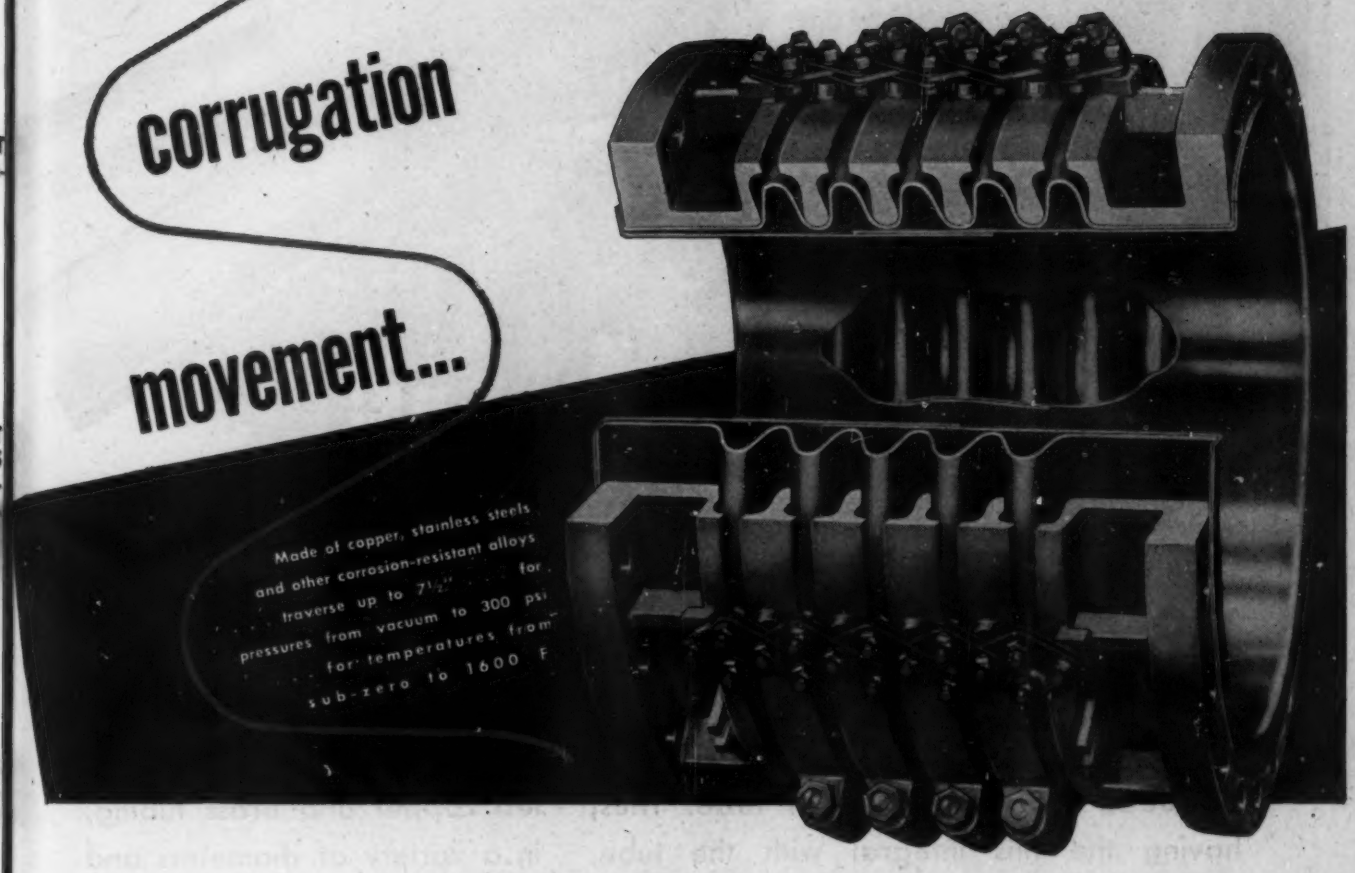
Vogt

DROP FORGED STEEL
INTEGRAL FLANGED
GATE VALVES

HENRY VOGT MACHINE CO., Inc.,
1000 WEST ORMSBY STREET LOUISVILLE 10, KENTUCKY

Branch Offices: New York • Chicago • Cleveland • Philadelphia • Dallas

positively controlled corrugation movement...


Made of copper, stainless steels and other corrosion-resistant alloys
traverse up to 7½"
for pressures from vacuum to 300 psi
for temperatures from sub-zero to 1600 F

...with Zallea Improved Duo-Equalizing* Expansion Joints

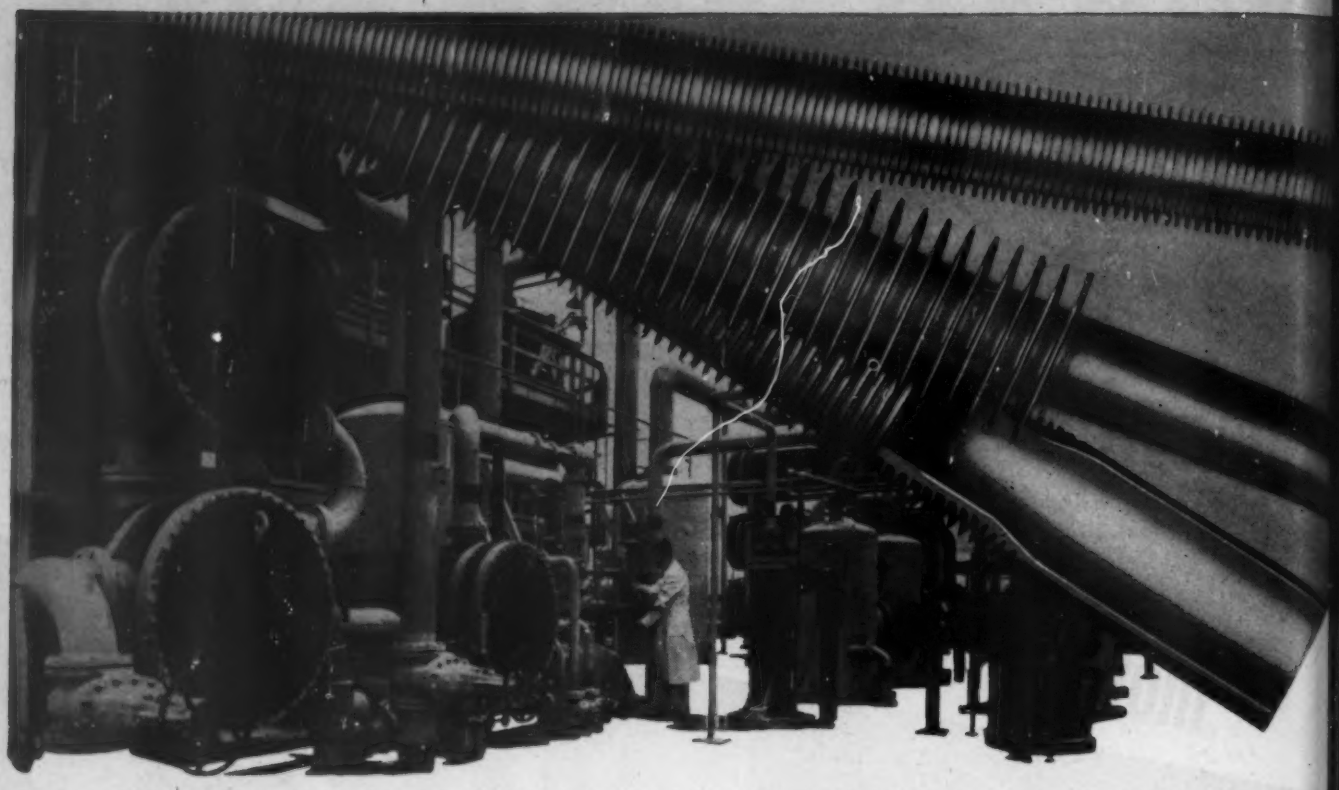
In any corrugated expansion joint no two corrugations are ever identical. Wall thickness varies slightly within the limits of mill tolerances for the particular metal, making some points heavier or lighter than others and thereby affecting the amount of flexing or displacement. In order that all corrugations shall flex equally they must have identical wall thickness and temper throughout the entire shape, *or they must be positively controlled.* Temper can be controlled through proper furnace annealing but wall thickness is only uniform within the limits of mill tolerances.

In Zallea Improved Duo-Equalizing Expansion Joints movement of the corrugations during both expansion and contraction is positively controlled by the equalizing rings. Rings are linked together by pantograph chains so that each one (and the corrugation it controls) must move equally and simultaneously with all others. Thus, irrespective of slight differences between corrugations it is impossible for one to move more or less than any other, resulting in an expansion joint that will endure under the severest service conditions.

For complete description and specifications of this unique and improved expansion joint write for Bulletin 45, or ask us to quote on your requirements.

*U. S. Pat. Pending

"Code-Craft"...
ZALLEA BROTHERS & JOHNSON
...EQUIPMENT FOR THE PROCESS INDUSTRIES
890 LOCUST ST. • WILMINGTON 99, DEL.



A view of the Firestone Tire & Rubber Co. plant at Lake Charles, La., which uses TRUFIN in the interchangers of the Carrier centrifugal refrigerating machines, chilling water for the condensation of vapors in the process of making synthetic rubber.

WOLVERINE TRUFIN IS SPECIFIED

for use where extreme heat changes are encountered

The fins of TRUFIN are extruded from the original tube. Thus, having the fins integral with the tube, TRUFIN possesses the distinction of being capable of withstanding extreme heat changes and severe vibrations—a quality, which, you will agree, is most desirable in heat exchangers. Here is dependability and economy!

TRUFIN is available, in seamless copper and brass tubing, in a variety of diameters and fin heights and spacings. It can also be bent and formed to meet any requirements.

Send for "TRUFIN Engineering Reports", which give you technical information about use of finned tube.

WHO'S WHO
AMONG WOLVERINE REPRESENTATIVES
E. J. CAMPBELL
208 Federal Sq. Bldg.
GRAND RAPIDS
MICHIGAN
will take care of your needs for Wolverine seamless copper and brass tubing in Western and Upper Michigan.

WOLVERINE

TUBE DIVISION

CALUMET & HECLA CONSOLIDATED COPPER COMPANY

1411 CENTRAL AVENUE • DETROIT 9, MICHIGAN

In Canada—Unifin Tube Co., London, Ont. ★ Southwest—Republic Supply Co., Houston, Texas

Patterson

PROCESS EQUIPMENT

Better

PETROLEUM PRODUCTS

PATTERSON

Satisfactory

MACHINERY

3 Distinguished Members OF A FAMOUS FAMILY

WALWORTH Bronze Valves

Walworth No. 95 can be used where throttling *is not* required. It is rated at 150 lbs. steam pressure at 500°F, and its improved renewable disc and lock-on, slip-off disc holder — an original Walworth development — saves time and trouble.

Walworth No. 225P is rated at 300 lbs. steam pressure at 550°F. With stainless steel, plug type discs — heat treated to a hardness of 500 Brinell — it can be closed on sand, slag, scale and similar flotage, without injuring the seating surfaces.

Walworth No. 29 is a double disc taper seat gate valve with a rising stem and union bonnet. It is rated at 200 lbs. steam pressure at 550°F. Valves can be repacked under pressure when fully opened.

These Walworth Quality Bronze Valves provide maximum protection against leakage by their union bonnet type construction, seats and discs of proper design, deep stuffing boxes, and tough bronze bodies. Further, they can be repacked under pressure when fully opened. Walworth Quality Bronze Valves are available in a full range of types and sizes, engineered to fit every service requirement.

For full details, write today — on your company letterhead — for Walworth Catalog 42.

14 AWARDS TO 4 PLANTS

WALWORTH
valves and fittings
60 EAST 42nd ST., NEW YORK 17, N. Y.

DISTRIBUTORS IN PRINCIPAL CENTERS THROUGHOUT THE WORLD

Not Magic but METHOD

Oil Blending and Grease Making has entered a new era with the advent of the

FLOW-MASTER Process

because it accomplishes in one continuous operation any or all of the following results.

It will mill solids in a liquid media under steady hydraulic pressure—texturize—blend—bleach—emulsify—stabilize and homogenize light or heavy viscous materials and produce perfectly stabilized products.

Processing Grease and Grease Compounds

It has no temperature limitations—It will incorporate dry or liquid substance into oils or greases and they stay in stabilization because they are processed by an entirely new and scientific treatment not accomplished heretofore by any other apparatus.

Oil bleed is greatly retarded if not eliminated and batch processing can be turned into continuous processing if desirable.

Oil Blending by the FLOW-MASTER Process

It will scientifically combine oils of various viscosities and densities to effect a blend in which molecular structure is controlled.

Coal and Oil Emulsions produced on the FLOW-MASTER are distinguished by their uniformity.

Bunker C. Fuel can be stabilized to such an extent that there is less sediment in storage tanks and the combustion can be vastly improved.

The apparatus can also be used in the manufacture of insecticides, sprays, wax and asphalt emulsions, etc.

If You Have A Pumping Problem

here is a pump that will solve it for you. It will handle anything that can be pumped and give you volume production. It works under high or low pressure—has high vacuum—constant non-pulsating delivery—automatic wear control—and no stuffing box trouble.

Send for Literature

THE FLOW-MASTER HOMOGENIZER

THE FLOW-MASTER PUMP WITH SPEED REDUCER

THE FLOW-MASTER KOM-BI-NATOR

MARCO CO. Inc., Third and Church Sts., Wilmington 50, Del.

Established 1936

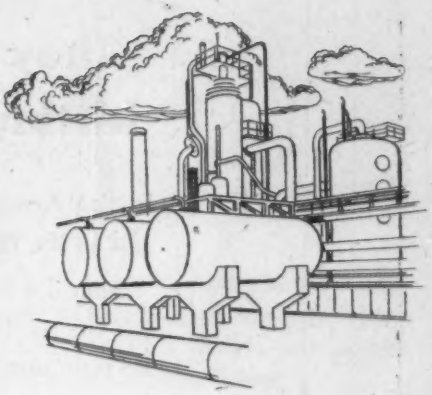
NOW...PERFECT TANK GAGING AT EYE LEVEL WITH THE NEW SMITH LIQUID LEVEL GAGE

Easy to install, even while tank is in service. Slip stream float is dropped down through 2" pipe – no internal guide wires needed. Three sizes for tanks of 25, 35 or 45 foot liquid height. High or low pressure–vapor tight for 2 or 300 PSI as required. It's revolutionary and inexpensive. May we give you complete information?

SMITH METER COMPANY

SUBSIDIARY OF A. O. SMITH CORPORATION
Factory — 5743 Smithway, Los Angeles 22, California
SALES OFFICES: NEW YORK, CHICAGO, HOUSTON, LOS ANGELES
Local Stocks at Convenient Points • Local Agents in All Principal Cities

Specially suited for refinery service



Oliver Fasteners

Because of the exacting requirements of refinery applications, your interests are best served by *specialized* fasteners. Knowing this, Oliver offers machine bolts, stud bolts, rivets and other headed and threaded products that will withstand the high temperature, corrosion, high stresses and other conditions that would shorten the life of ordinary fasteners.

Use our specialized knowledge and facilities in selecting and specifying your fasteners!

OLIVER
IRON AND STEEL
Corporation

SOUTH TENTH AND MURIEL STREETS • PITTSBURGH, PA.

They keep on hitting the ball

In the Army they hit the ball—and in the Navy, too!

They did their part in the biggest job the world ever saw. They did it "right now"! And that, say many letters about service men who have returned to our employ, is still their way of doing things. Here's a sample:

"Sunday, a rental battery fell out of my car. The plate which held the battery had rusted through. I managed to prop the battery in temporarily . . . then called at your station.

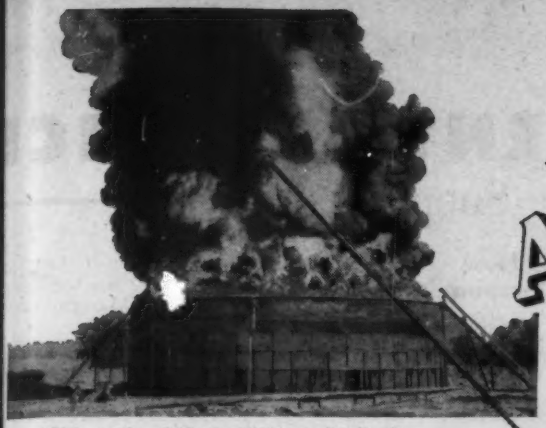
"Mr. Blank, the attendant, spent more than an hour devising a brace. Never have I seen a man work so hard on a task—a task which wasn't in the Standard of California kit of services. In fact, he worked past his closing time. For initiative, Blank—*who told me he was just out of the service*—has my vote. I congratulate Standard on having him."

To this we can add that everyone in our organization finds inspiration in the vigor and conscientiousness shown by returned service men toward their duties—whether they were with us before, or have come in since doffing uniform.

All through this war we have received letters from employees in uniform saying how eager they were to be back again with "the Company." We'd like to say right here and now how happy we are to have them back. Daily, they're giving us *new* reason to be proud of our returned service men.

STANDARD OF CALIFORNIA

E flag with 4 stars,
awarded to our Richmond Refinery



6800 sq. ft. of blazing light crude oil after burning 23 minutes.

AER-O-FOAM Put this Fire Out

Two minutes after Aer-O-Foam was started.

Three minutes later.

THE AER-O-FOAM BLANKET THAT DID IT

Only 375 gallons of Aer-O-Foam liquid were used to extinguish this fire in a 93 foot diameter tank, containing Illinois crude oil to a height of 19 ft. The fire was completely extinguished in a few minutes by applying Aer-O-Foam at the rate of .66 gallons per sq. ft. of oil surface per minute. Aer-O-Foam was applied at two points through National Type "L" Foam Chambers with Moeller Tubes.

Aer-O-Foam, developed by National Foam System, smothers fire with a thick, tough, enduring blanket. Tagged "Bean Soup" by the Navy, Aer-O-Foam does for peacetime industry the same superb job it did in war. It sticks to insulate flame-threatened flat or upright areas—it flows equally well to smother the hottest fires in petroleum, chemical, aviation and other industries.

National Foam, as powder or Aer-O-Foam liquid, fits every industry's post-war budget. Ounces of fire prevention save many million pounds in plants and materials. Foam's gas-tight blanket quickly extinguishes fires, prevents them from spreading, permits no flashbacks.

Don't wait for fire to cancel your peacetime expansion. Wire, telephone or write today to safeguard your progress. Our engineers are yours.

NATIONAL FOAM SYSTEM, INC.

SPECIALIZING IN FOAM FIRE PROTECTION

Packard Building, Philadelphia 2, Pa.

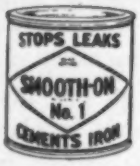
..MADE LEAK-PROOF

For lasting insurance against leaks at slip joints in cast iron economizer tubes and other locations, always set the joint with Smooth-On No. 1 Iron Repair Cement. That is the method used for years in a Washington, D. C. filtration plant. At 165 lbs. working pressure, with flue gases entering at 450° F., not one joint, sealed with Smooth-On No. 1 has ever developed leaks.

This typical Smooth-On "stitch-in-time" is one of many practical, time-saving, money-saving suggestions shown in the

FREE SMOOTH-ON REPAIR HANDBOOK

which you may secure by simply mailing the coupon. Cracks sealed. Leaks stopped. Loose parts and fixtures made fast. Pocket size. 40 pages. 170 diagrams. Clear, tested, short-cut directions. Handy index. Over 1,000,000 copies already put in circulation. A book every mechanic, engineer and repair man should have handy.



Smooth-On No. 1 is sold in 1-, 5-, 25-, and 100-lb. sizes at supply houses. If yours hasn't Smooth-On, contact us direct.

1895-1945 Half a Century of Dependable Service

Smooth-On Mfg. Co., Dept 11
570 Communipaw Ave.,
Jersey City 4, N. J.

Please send Smooth-On Handbook

Name_____

Address_____

12-45

Do it with SMOOTH-ON

About EQUIPMENT—SERVICE Suppliers

Pittsburgh Meter Company Now Rockwell Manufacturing Company

Stockholders of Pittsburgh Equitable Meter Company have approved change of the name of the company to Rockwell Manufacturing Co.

Directors of Pittsburgh Equitable Meter Company continue as directors of Rockwell Manufacturing Company. Willard F. Rockwell, for whom the company is named, is chairman of the board and president. Serving with him on the board are J. Frank Drake, Meredyth H. Ewing, Edgar W. Meyers, Henry A. Phillips and Willard F. Rockwell, Jr., Pittsburgh; John L. Merrill, Sven J. Nordstrom and Herbert S. Shuey, San Francisco; Elisha Walker, New York; and W. F. Crawford, Chicago.

Pittsburgh Equitable Meter Company will continue as a subsidiary of Rockwell Manufacturing Company, marketing measuring equipment manufactured in plants at Pittsburgh, Brooklyn and Hopewell, New Jersey.

The increasing scope of the company's manufacturing facilities and products prompted the change in the company name, it was said. In addition to Pittsburgh Equitable Meter Company, Rockwell Manufacturing Company is the parent Company of Merco Nordstrom Valve Company, Oakland, California; Rockwell Machine Company, Hopewell, New Jersey; The Edward Valve & Manufacturing Company, East Chicago, Indiana; Delta Manufacturing Company, Milwaukee; V. & O. Press Company, Hudson, New York; Crescent Machine Company, Leetonia, Ohio; Rockwell International Corporation, New York, and Monessen Foundry & Machine Company, Monessen, Pennsylvania.

Merco Nordstrom Valve Company, has shortened its name to Nordstrom Valve Company.

Officers of Rockwell Manufacturing Company include W. F. Rockwell, president; W. F. Rockwell, Jr., vice president and general manager; J. Frank Drake, W. S. Potter and A. J. Kerr, vice presidents; H. A. Phillips, vice president and secretary; Edgar W. Meyers, treasurer; and E. W. Meyers, Jr., controller.

Fisher Governor Company Appoints Houston Representative

Fisher Governor Company, Marshalltown, Iowa, has announced appointment of Puffer-Sweiven Company as its exclusive representative in the Texas Gulf Coast area. The company has offices at Room 605, Merchants & Manufacturers Building, Houston 2, Texas.

Kenneth L. Puffer has been associated with Fisher Governor Company for more than 20 years, both as a member of the Marshalltown engineering and research staff and as a sales engineer in the field. Since 1933 he has served the Gulf Coast area from the Houston office.

C. E. Sweiven has had seven years' field experience in selling and servicing Fisher control equipment. Prior to his affiliation with the Fisher organization, he spent several additional years in the automatic control field. For the past two years he has sevred in the home office as sales engineer.

C. E. Sweiven

K. L. Puffer

Kerley Appointed on Ethyl Technical Staff

Robert V. Kerley has joined the technical staff of Ethyl Corporation as director of aeronautical research, a post left vacant by the resignation of S. D. Heron, who will continue to serve the staff as special consultant.

R. V. Kerley

Kerley has been a civilian engineer with the engineering division of the United States Army Air Forces at Wright Field since 1932, and has been chief of the fuel and oil branch, power plant laboratory of the Air Technical Service Command since 1936.

His headquarters will be in Detroit.

Combustion Engineering Names R. M. Hatfield to Sales Post

Robert M. Hatfield has resigned as deputy vice chairman of the War Production Board to become assistant general sales manager of Combustion Engineering Company.

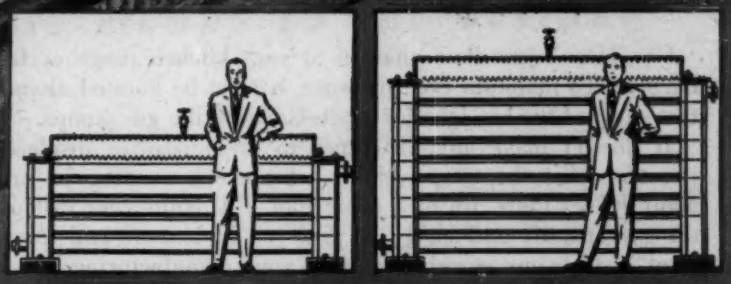
R. M. Hatfield

A mechanical engineering graduate of Purdue University, 1932, Hatfield joined Combustion Engineering Company in 1934 as a student engineer, subsequently serving as sales engineer at Cleveland. In 1942 he went to Washington as chief of the boiler section of the power branch, WPB, and later became director of the production scheduling division. He resigned from WPB in May, 1944, to accept a commission in the Navy, and in November of that year was assigned back to WPB to take charge of the Navy repair parts program. Last April he was placed on inactive status by the Navy to become deputy vice

Announcing

THE NEW KARBATE SECTIONAL CASCADE COOLER

MADE UP OF FOUR STANDARD PARTS In any of Five Pipe Sizes



It's quick and easy to increase or decrease the capacity of your "Karbate" Sectional Cascade Cooler.

HERE'S a cascade cooler that you can order from stock to suit your particular process needs. Its interchangeable sections make construction—and additions or subtractions—a quick and easy matter.

Nine-foot-long, single-pipe "Karbate" cooler sections are stacked to form a series flow vertical bank. The compact joint construction makes possible close pipe spacing, and ends the need for redistribution baffles. Also, no external supports are necessary. Maximum effective external areas: about 120 sq. feet in all five pipe sizes in the maximum recommended cooler height of six feet.

Gaskets are of synthetic rubber or of asbestos composition, as desired. A standard steel water distributor is mounted atop the steel tie rod assemblies.

Has many uses! Made of "Karbate" impervious graphite material, the Sectional Cascade Cooler is ideal for efficient cooling of almost all acids, caustics, and organic solvents at pressures up to 75 lbs. p.s.i., and temperatures up to 338° F. With minor changes in applying the cooling water, gases well above this temperature can be handled.

For engineering details on this Sectional "Karbate" Cascade Cooler, ask our nearest Division Office for a copy of Bulletin M-8807.

The words "National" and "Karbate" are registered trade-marks of National Carbon Company, Inc.

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide and Carbon Corporation

UCC

General Offices: 30 East 42nd Street, New York 17, N. Y.

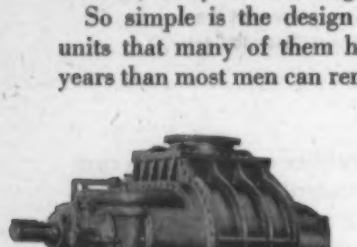
Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

PLENTY OF BOOST REQUIRED

• Gas doesn't just flow unaided to your kitchen range or factory burners. To maintain even pressure, it must be boosted along, and that's one of the big jobs for Roots-Connersville gas pumps.

It doesn't make any difference to these positive displacement boosters what the temperature or barometer reading is, or how many BTU's there are in a cubic foot, R-C equipment just pushes the gas, steadily and surely, to give you fuel where and when you want it, for your morning eggs or your manufacturing processes.

So simple is the design and so sturdy the construction of R-C units that many of them have been in profitable service for more years than most men can remember. Some applications are:



Every minute, this heavy-duty R-C unit pumps 15,000 cubic feet of manufactured gas. Equally sturdy and dependable R-C units are available down to 10 CFM capacity.

Proportioning and mixing gases
Acid-making processes
Foundry cupolas
Ore concentrators
Vacuum filtration processes
Paper folding machines
Chemical and food processing
Cooling cannery packs

The continued fine performance of R-C units is the result of our *dual-ability* to engineer and build to the most exacting specifications. If you have a problem of moving air, gas or liquids under moderate pressures, consult us.

ROOTS-CONNERSVILLE BLOWER CORP.
One of the Dresser Industries
512 Crescent Ave., Connersville, Indiana

Roots Connersville Since 1854

ROTARY POSITIVE AND CENTRIFUGAL BLOWERS • EXHAUSTERS • BOOSTERS
LIQUID AND VACUUM PUMPS • METERS • INERT GAS GENERATORS

chairman for Production of WPB which position he held until the board was abolished on November 2.

Graff Organizes Gas Engineering Company

Robert A. Graff has resigned as chief process engineer in the gas processes division of Girdler Corporation and has organized Graff Engineering & Equipment Company, at 505 South Third Street, Louisville, Kentucky. This company will engage in general gas engineering, offering specialized service in the field of gas production, purification and dehydration equipment.

R. A. Graff

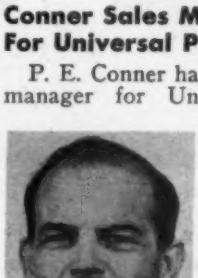
D. H. Hyler Joins Republic Supply Company at Houston

D. H. Hyler has joined the sales staff of Republic Supply Company and will have headquarters at the general sales offices of the company in Houston, where his particular assignment will be in connection with refinery and industrial sales. Before joining Republic Supply Company, Hyler spent 30 years in active refinery operations. For the past 21 years he has been connected with Continental Oil Company, and for 19 years has been in charge of that company's Wichita Falls refinery.

D. H. Hyler

Conner Sales Manager For Universal Packing

P. E. Conner has been appointed sales manager for Universal Packing and Gasket Company, Houston. A former employe of Humble Oil & Refining Company, Conner also spent three years as exploration engineer in South America for Standard Oil Company (New Jersey) and seven years as geophysical supervisor for The Pure Oil Company. In 1936 he joined Reed Roller Bit Company to handle the Louisiana territory. He was loaned to PAW in 1945.



P. E. Conner

J. R. Hertzler Elected York Corporation Vice President

John R. Hertzler has been elected a vice president of York Corporation, having returned to that organization following his recent release from Navy duty. After serving in Washington for 39 months as liaison officer of the Army-Navy munitions board with the rank of lieutenant commander.

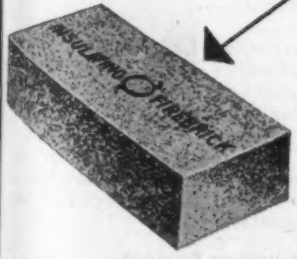
Except for the time in Washington, Hertzler has spent his business career with York Corporation. Graduating from

...and what this means to the refiner

The above statistical information can be interpreted by the refiner to his distinct profit.

B&W Insulating Firebrick were not chosen by the builders of these furnace units by chance, but by experience—the experience of the country's most expert and informed buyers of refractories.

These manufacturers *know* refractories. They realize the significance of temperature ratings, brick weight, hot-load strength and similar technical data. That is why they chose B&W Insulating Firebrick for 80 units which they built to produce synthetic rubber from petroleum. Their judgment is well worth following when you order refractory replacements. By doing so, you can be sure you will get insulating firebrick that fill *all* the requirements of insulating firebrick—low heat conductivity, low heat-storage capacity, rapid cooling when fires are shut off, and long life under direct exposure to furnace gases—with consequent fuel saving and minimized maintenance of furnace linings.



R-222

B&W

Water-Tube Boilers, for Stationary Power Plants, for Marine Service . . . Water-Cooled Furnaces . . . Superheaters . . . Economizers . . . Air Heaters . . . Pulverized-Coal Equipment . . . Chain-Grate Stokers . . . Oil, Gas and Multifuel Burners . . . Seamless and Welded Tubes and Pipe . . . Refractories . . . Process Equipment.

BABCOCK & WILCOX

THE BABCOCK & WILCOX CO.
REFRACTORIES DIVISION
85 LIBERTY STREET, NEW YORK 6, N.Y.

EXPLOSION-PROOF AUTOMATIC FLOW CONTROL for liquids and gases.

★ **Do you want a device that *in an emergency* will instantly and automatically swing into action and cut off the flow of a liquid or gas?**

Use the ASCO Solenoid Valve.

★ **Do you want a flow to be started instantly and automatically *in an emergency*?**

The proper type of ASCO Solenoid Valve will perform this function, too.

★ **Do you want this service on lines carrying explosive or inflammable products?**

ASCO Explosion-Proof Valves are designed for this duty.

There are so many places where the Solenoid Valve fits into the refinery picture for automatically controlling the flow of liquids or gases that we suggest you send for our latest illustrated Circular No. 264. If you have the places for these valves already picked out, write us for our recommendations.

ASCO Solenoid VALVES

We also manufacture a quality line of Automatic Transfer Switches, Remote Control Switches, Contactors and Relays.

Automatic Switch Co.

41-F EAST 11TH STREET NEW YORK 3, N. Y. 12-AS-1

Lehigh University in 1927 with a degree in mechanical engineering, he spent two years in the company's shops as part of the graduate engineering course. Subsequently he was with the field organization, and later returned to the factory to assist in organizing and supervising the air-conditioning department. Later he transferred to sales and advanced to general sales manager. He is a member of the American Society of Heating and Ventilating Engineers and of the American Society of Refrigerating Engineers.

Kramer Sales Executive For Hammond Iron Works

Ralph E. Kramer has been elected vice president in charge of sales for Hammond Iron Works, Warren, Pennsylvania. This company recently has developed new features in variable-volume tanks, and an announcement says that in line with a planned policy of technical improvement, soon will announce other new products.

R. E. Kramer

Kramer is a graduate of Carnegie Institute of Technology. He was mill foreman for Inca Mining & Development Company in Tirapate, Peru; manager in the Far East for Sullivan Machinery Company, with headquarters at Tokio; president of H. Channon Company, and prior to joining Hammond Iron Works was sales manager for N. A. Woodworth Company, Detroit.

Brooks Rotameter Company Organizes to Make Instruments

Stephen A. Brooks and seven associates have organized Brooks Rotameter Company, Lansdale, Pennsylvania, to specialize in manufacture of rotameter flow-rate instruments designed to meet the difficult services and corrosive atmospheres encountered in the process industries.

S. A. Brooks

Brooks is a graduate chemical engineer and for the past six years has been vice president in charge of sales and advertising for Fischer & Porter Company. Each of his associates in the venture have had experience in rotameter engineering.

Gellhorn Resumes Export Post With Worthington

George Gellhorn, who left Worthington Pump and Machinery Corporation on January 1, 1942, for active duty in the United States Navy, has been released to inactive status and has returned to resume his position as export manager with offices at Harrison, New Jersey.

During his term of duty, Commander Gellhorn was assistant naval attaché at Buenos Aires, executive officer at the Naval Base in Bahia, Brazil, executive officer aboard the U. S. S. Albermarle, and navigation officer of the U. S. S. Gambier Bay, which was sunk by enemy

A neat trick that takes INSTINCTIVE BALANCE

The way she does it, the swinging door could be a garden gate . . . her heavy tray an armful of flowers! There's not a second's hesitation in her smooth, unwavering glide to your table. That's what you call INSTINCTIVE BALANCE . . . extra responsiveness at the very instant of upset. It's the *extra* correction that restores balance faster, smoother.

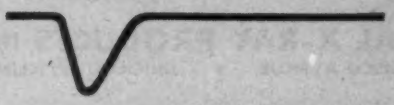
That's exactly how the Foxboro Stabilog with HYPER-RESET maintains perfect balance in a manufacturing process . . . going one step, an extra step, beyond mere mechanical responsiveness of ordinary process-control instruments. This extra action, precise, simultaneous, and superimposed upon ordinary corrective action, cuts recovery time to as little as one-fourth; boosts both quality and quantity of production. See for yourself:

WITHOUT HYPER-RESET

This is the curve of the best possible stabilization of a typical process possible before HYPER-RESET. For some processes, this recovery time could be satisfactory; but for others, it might impair quality very seriously.

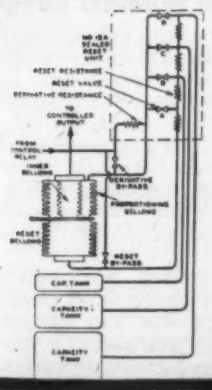
WITH HYPER-RESET

Now here is the stabilization curve of the same process using the Foxboro Stabilog with HYPER-RESET.



The contrast in recovery time is sharp . . . and still sharper when interpreted in terms of increased quantity, improved quality.

We'll welcome the opportunity to supply full details about Stabilog Control with HYPER-RESET. Write **The Foxboro Company, 74 Neponset Ave., Foxboro, Mass., U. S. A.**



Why HYPER-RESET Requires Only *1* Adjustment

An exclusive practical advantage of the HYPER-RESET Stabilog Controller is its simplicity of manipulation. The patented HYPER-RESET feature provides simultaneous setting of both the reset and rate-sensing functions.

A definite pressure drop across the derivative resistance for every rate of change in the measuring system produces an extra increment of correction.

Only one adjustment is necessary because each reset adjustment valve connects the derivative resistance to a different capacity in the network. (See diagram at left.) Since the proportioning system is automatically self-balancing, the use of a derivative resistance requires a greater quantity of air to maintain equilibrium. In producing this greater flow, a different pressure drop is established by each adjustment. Hence, the effective value of the fixed derivative resistance is really dependent upon the capacity in series with it – and requires no independent adjustment.

FOXBORO Stabilog Controllers

REG. U.S. PAT. OFF.

METAL-TO-GLASS SEALS

Intricate glass work and tubes made to your specification

The Universal X-Ray plant specializes in the production of metal-to-glass seals. Intricate glass seals are made to customers' specifications for electronic tubes, transformers, resistors, capacitors, condensers, vibrators, switches, relays, instruments, gauges, meters, receivers, transmitters, and other scientific apparatus.

A strong metal-to-glass bond assures unfailing protection against rust, corrosion, and extreme climatic conditions in a vacuum-tight seal. Good deliveries can be made on volume orders. Submit your metal-to-glass seal problems to the Universal engineers for recommendations and estimates.

UNIVERSAL X-RAY PRODUCTS INC.
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fire during the Battle for Leyte Gulf. In this latter encounter, he was rescued by another United States warship after being in the water for 45 hours.

Before receiving his orders to report for active duty, Gellhorn had been in the service of Worthington Pump and Machinery Corporation for over 11 years.

Booth Sales Manager for Wilson-Snyder Division

Howard W. Booth has been appointed manager of sales for Wilson-Snyder Manufacturing Division of Oil Well Supple Company, Braddock, Pennsylvania.

H. W. Booth

Booth was assistant to the chief engineer of Oil Well Supply Company for 12 years, prior to which he served in an engineering and production capacity with Wilson-Snyder.

He entered the employ of Wilson-Snyder immediately after graduation with a degree in mechanical engineering from Penn State College in 1930.

Republic Supply Company Shifts Texas Representatives

H. T. Hopkins has been appointed assistant district manager for Republic Supply Company at Kilgore, succeeding Tom C. Hendricks, who has been transferred to Wichita Falls as district manager. Hopkins has served Republic at various points throughout the southwest since February, 1923, and has been located at Kilgore since February, 1939. He will continue to make his headquarters at Kilgore but will serve as assistant to J. B. Lionberger, district manager at Shreveport.

H. T. Hopkins

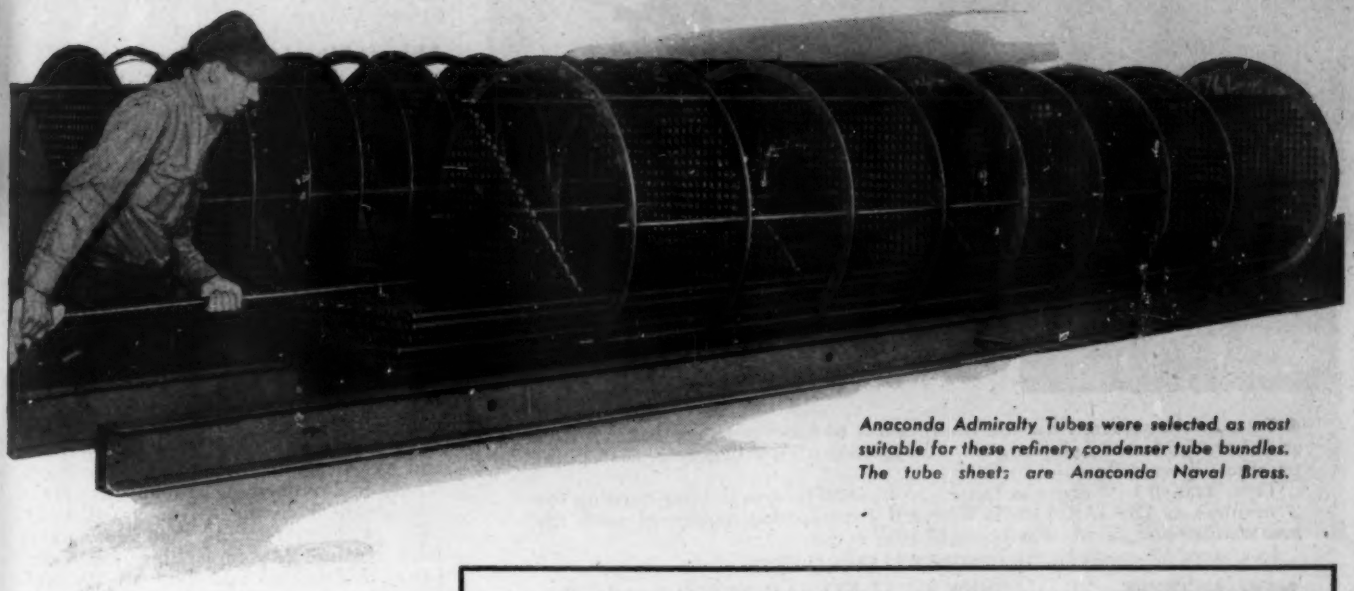
R. M. Deanesley Joins Staff of Universal Oil Products Company

R. M. Deanesley, recently with The M. W. Kellogg Company and Kellex Corporation, has joined the research staff of Universal Oil Products Company. He will be in charge of a new department which is being established in the company's Riverside laboratories.

While with Kellex Corporation, Deanesley did important work in connection with separation of U-235 by gaseous diffusion.

Born in England and educated at Oxford and at University College, London, Deanesley has had extensive experience in the petroleum industry, especially in the light-hydrocarbon field, having been associated with Shell Development Company for 15 years before joining the Kellogg organization. His activities have included work on production of iso-octane, catalytic polymerization of olefins, and other catalytic processes related to production of aviation gasoline, and development of processes for chlorination, sulfation and hydration

Which Condenser Tube Alloy is best suited to YOUR needs?



Anaconda Admiralty Tubes were selected as most suitable for these refinery condenser tube bundles. The tube sheets are Anaconda Naval Brass.

THE TUBES being installed in this refinery condenser are made of Admiralty Alloy. This alloy is widely used in the petroleum industry . . . yet is not necessarily the one best suited to *your* needs.

Anaconda Alloys for condenser and heat exchanger tubes are made in the standard compositions listed in the table (right). In addition, The American Brass Company produces several special alloys for use under severe or unusual conditions of service. All are produced under close technical control, to rigid specifications.

The broad experience of our Technical Department is available in making a study of these alloys in relation to your needs.

NOMINAL COMPOSITIONS OF ANACONDA CONDENSER TUBES

Alloy	Alloy No.	Copper %	Nickel %	Zinc %	Aluminum %	Tin %	Arsenic %	Phosphorus %
Admiralty Alloy	442	70	..	29	..	1	..	..
Arsenical Admiralty	439	70	..	28.95	..	1	0.05	..
Ambraloy (*Aluminum Brass*)	927	76	..	21.95	2	..	0.05	..
Ambraloy (*Aluminum Bronze*)	901	95	..	..	5	..	..	..
Super-Nickel	701	70	30	..	..	..	..	..
Cupro-Nickel	712	80	20	..	..	..	..	..
Ambrac*	850	75	20	5	..	..	..	..
Red Brass (85%)	24	85	..	15	..	..	..	..
Muntz Metal	65	61.5	..	38.5	..	..	..	..
Deoxidized Arsenical Copper	108	99.68	..	..	..	..	0.30	0.02
Deoxidized Copper	939	99.9+	..	..	..	..	..	0.02

*Trade Mark Reg. U. S. Pat. Off.

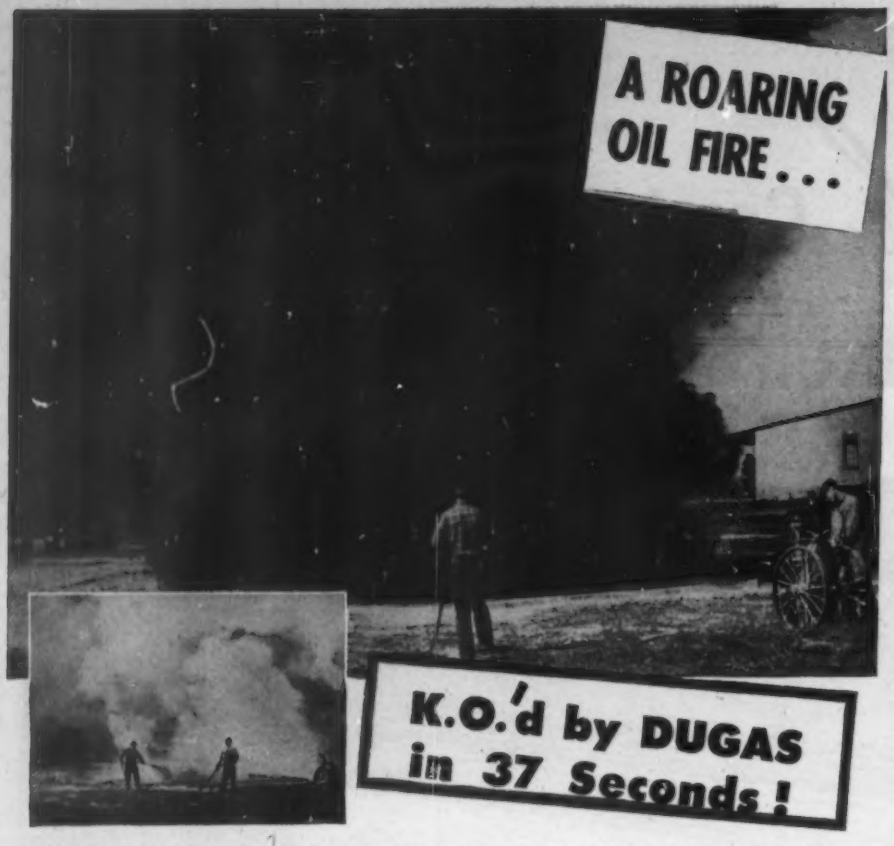
Buy VICTORY BONDS . . . Help Assure World Peace

ANACONDA

Anaconda Condenser Tubes

THE AMERICAN BRASS COMPANY • General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company • In Canada: ANACONDA AMERICAN BRASS LTD., *New Toronto, Ont.*



K.O.'d by DUGAS in 37 Seconds!

● In a test conducted for the observation of Underwriters' Laboratories and Factory Mutual Laboratories, 500 gallons of 300 degree F. flash point paraffin oil were "touched off."

This "transil oil" fire was large (20 ft. x 20 ft. area). After burning for 2 minutes, a DUGAS 150-A Wheeled Extinguisher equipped with the *new dual-stream nozzle* was brought into action.

In a mere 37 seconds, the inferno was extinguished.

NEW NOZZLE STEPS UP EFFECTIVENESS

NEW DUAL-STREAM NOZZLE deals effectively with spill fires and fires difficult to reach because of height or obstructions. Designed for use with DUGAS Wheeled Extinguishers, the new Dual-Stream Nozzle greatly increases fire-fighting range and effectiveness. A turn of the handle gives a *straight* stream with a range of 45 feet—or a *fan* stream with a range of 15 feet.

QUICK FACTS ABOUT DUGAS DRY CHEMICAL

1. For extra-hazardous fires involving flammable gases, liquids, greases or electrical equipment.
2. Not an electrical conductor.
3. Non-toxic, non-corrosive, non-abrasive.
4. Not affected by extreme cold or heat.

Write today for complete information regarding DUGAS Wheeled Extinguishers with the new Dual-Stream Nozzle... and DUGAS Hand Extinguishers.

AN ANSUL PRODUCT
THE MASTER OF FLAME

Approved by Underwriters' Laboratories, Factory Mutual Laboratories

DUGAS 150-A WHEELED EXTINGUISHER

ANSUL CHEMICAL COMPANY, MARINETTE, WISCONSIN
DUGAS DIVISION

of hydrocarbons, and azeotropic rectification. His inventions have brought him a number of patents.

Deanesley is a member of the Institution of Chemical Engineers of Great Britain, American Chemical Society, and Society of Chemical Industry.

Carpenter Steel Names Two to Sales Assignments

Carpenter Steel Company, Reading, Pennsylvania, has named F. A. Guba eastern manager of sales for its line of stainless tubing. He will have headquarters at the Kenilworth, New Jeresy, office. F. D. Archer has been named midwestern sales manager and will have headquarters at 221 North LaSalle Street, Chicago.

Abbott Heads New Products Division Pennsylvania Salt

Fred C. Abbott has been appointed manager of the new products division of Pennsylvania Salt Manufacturing Company, Philadelphia. He has been in the market research and sales departments of the company since 1943. In his new capacity he will direct the introduction and sale of the new products that come out of the company's research program.

Tivy Assistant Manager of Foxboro; Swanson Appointed

V. V. St. L. Tivy has been appointed assistant manager, oil and gas industries sales division of The Foxboro Company and has assumed his duties at the home offices in Foxboro, Massachusetts. He is a graduate from the Royal Naval Academy in England and had connection with Neal & Massy Engineering Company of Trinidad and The M. W. Kellog Company before joining Foxboro.

Nels A. Swanson who has joined Foxboro as a sales engineer attached to the Los Angeles branch office, previously was with Goodyear Synthetic Rubber Corporation.

Gottwald Goes to South America For Meter-Valve Companies

H. Gottwald, for 17 years a service engineer for Pittsburgh Equitable Meter Company-Nordstrom Valve Company in the metropolitan New York territory, has been assigned to Rockwell International Corporation. Rockwell International Corporation is the new name for the organization formed as Pittsburgh International Corporation to handle export sales and service of the company's products. Gottwald has been appointed special representative for Latin America and is making a preliminary trip covering the important markets in South America.

Stearns-Roger Sponsors Colorado Gas Research

Large scale experimental studies to improve the equipment for natural-gas pipe lines are now being conducted by the Engineering Experiment Station of the University of Colorado for Stearns-Roger Manufacturing Company of Denver.

Two 14-foot high reaction towers are part of the equipment being erected at the laboratories of the station as the research engineers under Dr. J. E. Stepanek, assistant professor of chemical engineering, began assembling the equipment for the projects.

"We are trying to develop improved

Designed for the particular needs of industrial process blending of fluids, this new direct-drive Pulsafeeder proportioning pump offers singular advantages. *Hydraulically-balanced diaphragm head* isolates piston and cylinder from fluids being pumped, eliminates need for packing glands, prevents contamination of product by pump, lubrication or packing; protects pump from corrosion or attack by fluid being pumped.

Box-type construction provides *sealed-in* lubrication, with all moving parts (except motor) running in an oil bath. Rate of flow *continuously adjustable while machine is in operation* by hand wheel, from zero to full maximum. Largest unit has maximum pumping rate of 800 gallons per hour. Literature and specifications on request. *Process Equipment Division, Lapp Insulator Co., Inc., 150 Maple St., LeRoy, N. Y.*

Lapp *Process Equipment*

Scientific Rust Control

PROTECT YOUR METAL SURFACES FROM CORROSION WITH

RUST-OLEUM

"The Miracle Paint"
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QUICK REPAIRS ON
CONDENSERS
and
HEAT EXCHANGERS

If you need condenser or heat exchanger repairs in a hurry call us. We specialize in fast, high quality work.

25 Years Successful Experience

GULF ENGINEERING CO., INC.

methods for removing water vapor from natural gas so that the pipe lines will not freeze up and stop the flow," Dr. Stepanek explained. Even on days when the temperature is above the normal freezing temperature, high-pressure gas lines will freeze and plug if there is too much water vapor present in the gas.

The research engineers will also do pilot-plant studies on the efficiency of other types of equipment used in high-pressure gas transmission.

According to officials this work is the beginning of an expanded research program by Stearns-Roger Manufacturing Company in many phases of chemical and petroleum engineering.

Harry E. Clark Opens Dallas District Office

Harry E. Clark & Company, Houston, has opened a sales and service branch at Dallas, to be in charge of Henry L. Litchfield, recently a captain in the air force. The company recently was appointed distributor for Strong, Carlisle & Hammond steam products and will stock those items at Dallas.

Bickler Goes to Los Angeles For Globe Steel Tubes Company

C. J. Bickler has been appointed manager of sales at its Los Angeles office by Globe Steel Tubes Company of Milwaukee.

Bickler has been with the company since 1923. During the past three years he has been at Milwaukee as assistant to the vice president in charge of sales, and in charge of the welded tube division. Prior to that he was manager of sales at Cleveland.

ASTM Standards on Petroleum Products and Lubricants

This latest compilation of ASTM Standards on Petroleum Products and Lubricants brings together in convenient form over 80 specifications, tests, and definitions that have been standardized through the work of Committee D-2 on Petroleum Products and Lubricants.

In addition to the current report of the committee, there are several appendices covering the following: results of tests on method for estimating maximum pour points of lubricating oils containing pour point depressants, and two proposed methods covering a test for maximum pour point and total olefinic and aromatic hydrocarbons in gasoline.

The specifications cover cut-back asphalts—rapid and medium curing type, emulsified asphalts (five types), petroleum spirits, Stoddard solvent, thermometers, fuel oils, gasoline, etc.

The large number of test methods provide authoritative procedures for determining properties of a wide range of petroleum products, for example, acid heat of gasoline, aniline point, ash content, autogenous ignition temperatures, aromatics, olefins, benzene and isopentane insolubles, crankcase oils, knock characteristics of fuels, specific gravity, color, distillation, melting point, viscosity-temperature charts (Saybolt and kinematic), etc.

Copies of this 530-page compilation can be obtained from ASTM Headquarters, 260 S. Broad St., Philadelphia 2, at $2.75 each with special prices on orders in quantity.

Gholson Now With Hovey Petroleum Company

Aubrey T. Gholson returning from the armed services is now associated with Hovey Petroleum Company at Houston. Prior to Army service Gholson was a deputy petroleum inspector approved by the New York Produce Exchange and was closely identified with petroleum inspection work, both foreign and domestic, for 12 years.

Latin-American Sales Opportunity

Experienced equipment sales engineer is organizing sales representative organization to perform a specialized oil industry service in Latin-American countries for a limited group of non-competitive equipment manufacturers.

Interested in contacting one or two additional manufacturers who can profit from sales representation by experienced oil men who have lived abroad, know the people, the language, conditions and sales opportunities.

References will satisfy any investigation and ample finances to support any sales requirements.

For further details send correspondence to Box 66-R, c/o Petroleum Refiner, Houston, Texas.

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CONCRETE LININGS

FOR:

BUBBLE TOWERS • STILLS • HOT OIL SEPARATORS • STORAGE TANKS • REFINERY VESSELS OF ALL TYPES • ENCASING AND FIREPROOFING STRUCTURAL STEEL AND PIPE • LINING WATER STORAGE RESERVOIRS, DITCHES AND CANALS • REPAIRING DISINTEGRATED CONCRETE AND MASONRY.

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we have pleasure in offering the following new Processes:—

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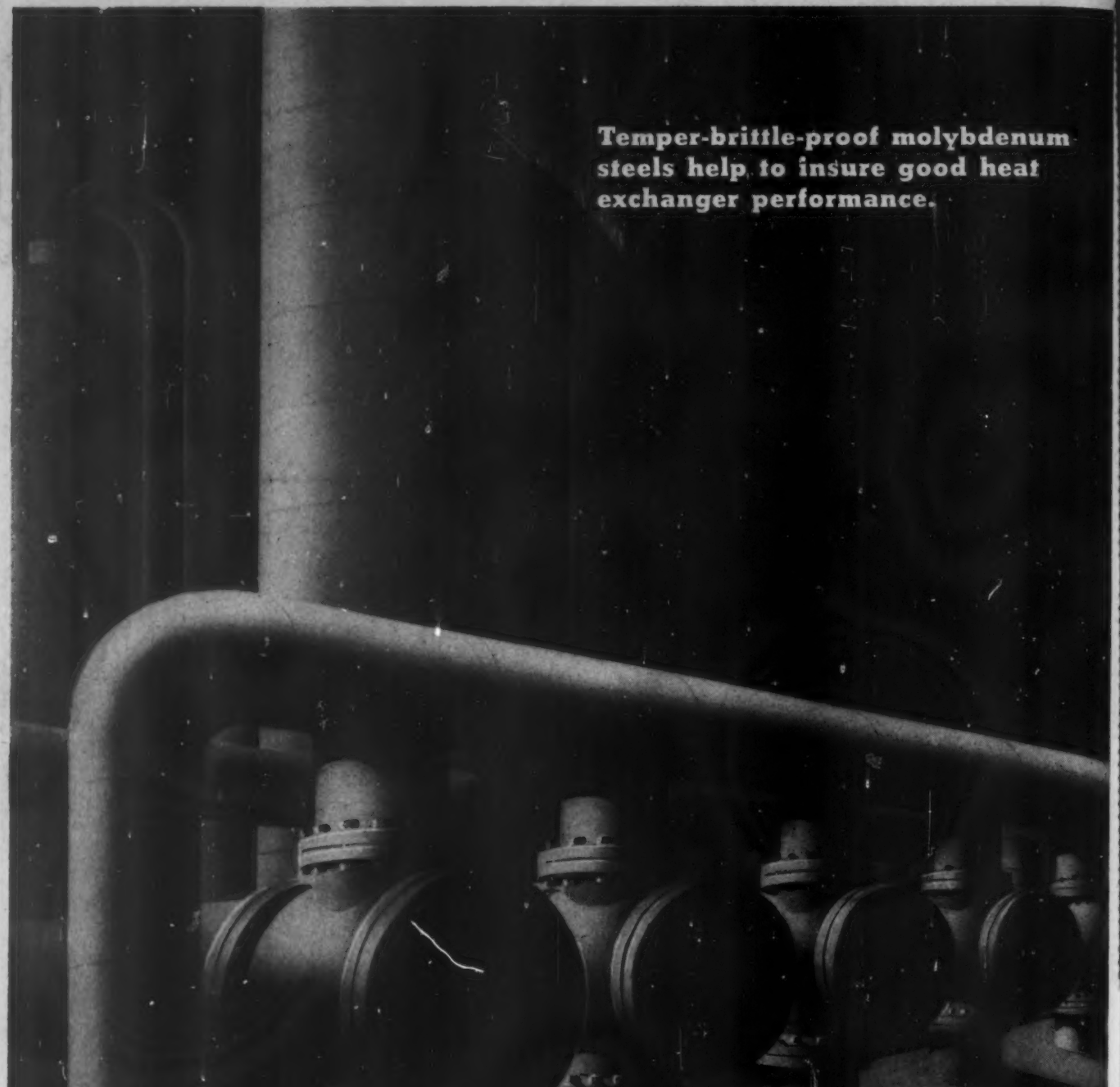

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

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MOLYBDIC OXIDE, BRIQUETTED OR CANNED • FERROMOLYBDENUM • "CALCIUM MOLYBDATE"

Climax Molybdenum Company

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MOLY

NEW EQUIPMENT

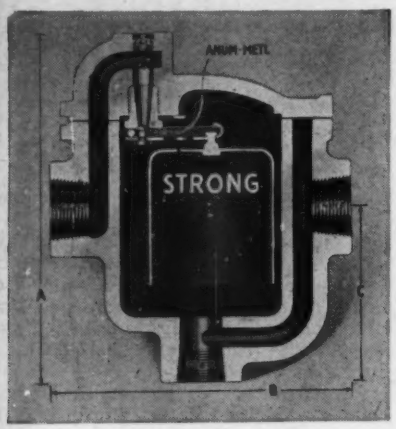
...MANUFACTURERS' · LITERATURE...

FOR FREE COPIES OF MANUFACTURERS' LITERATURE OR MORE INFORMATION ON PRODUCTS DESCRIBED ON THESE PAGES, USE THE MAILING CARD INSERTED IN THIS ISSUE

1—Steam Trap

Strong, Carlisle & Hammond Company, 1392 West Third Street, Cleveland 13, Ohio, has announced a new series of industrial steam traps of the inverted bucket type.

Features include a new, scientifically designed orifice throat which gives up to 25 percent greater capacity, avoids turbulence, and minimizes choking caused by flash steam. The screwed-in valve seat is renewable for easy servicing. A new lever construction gives quick full opening without dribbling.



Strong Steam Trap

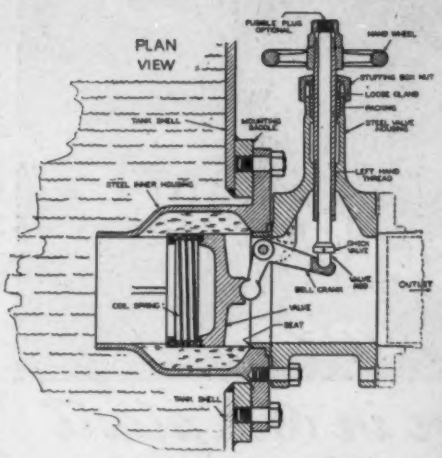
The straight-through inlet-outlet connections have been relocated to place the trap below the inlet pipe at all times. The traps are available in three body sizes up to 1¼-inch in both standard and thermal design.

Catalog No. 67 gives full description, sizes and capacities.

2—Internal Tank Valve

Oceco Division of The Johnston & Jennings Company, Cleveland 14, Ohio, has announced the Oceco V-104 internal tank valve to safeguard the contents of storage tanks against run-off in event of line breakage. It permits flow to be shut off to make repairs or alterations in the line, and can be closed manually, or automatically through the melting of a fusible plug, to prevent the tank contents from feeding a fire.

The valve is mounted on a saddle which is welded to the tank shell. Turning the hand wheel to the left forces the valve rod downward. This actuates the bell crank, pushing the valve inward, putting the spring under compression and permitting the fluid to pass outward. Reversing the hand wheel releases pressure on the spring, which reseats the valve, stopping the flow. The fusible plug, furnished when desired, melts at critical temperature, releasing the valve rod and cutting off the flow in case of fire.



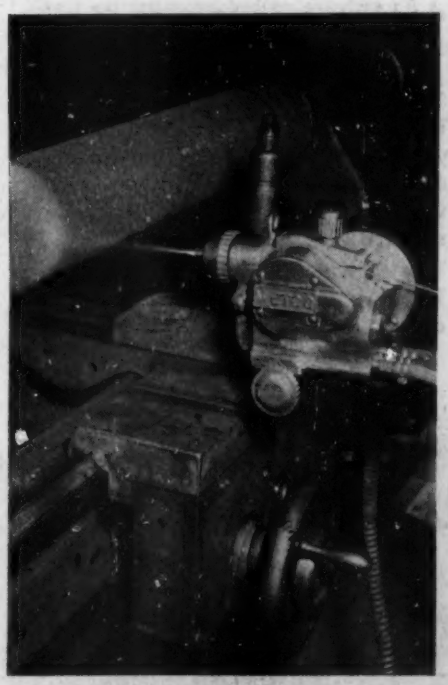
Oceco V-104 Internal Tank Valve

The valves have steel bodies, valve rods and bell cranks, and bronze or stainless-steel trim, with or without the fusible plug. Sizes 4-, 6-, 8- and 10-inch are standard, or can be made in other sizes on special order.

3—Metalizing Gun

Metallizing Engineering Company, 3814 30th Street, Long Island City 1, New York, is introducing a new metallizing gun, Type Y, designed specifically for mechanical mounting and continuous operation. This gun is much heavier and more rugged in construction than this manufacturer's hand guns.

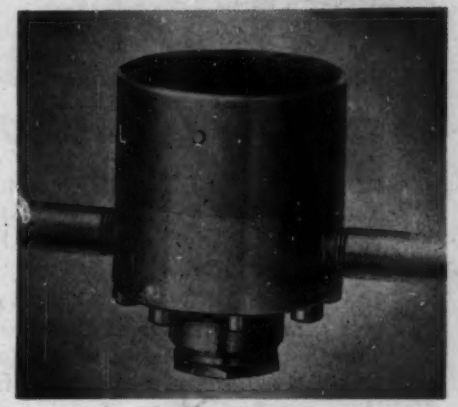
Bulletin 49P describes the unit in detail.



Metco Metallizing Gun

4—Pressure Regulator

Grove Regulator Company, 6541 65th Street, Oakland 8, California, has announced a small and compact regulator weighing less than 2 pounds and measuring 2¾x3¼ inches and suitable for handling initial pressures up to 3500 pounds with adjustable control range from 5 to 1500 pounds. Special models can be supplied for higher initial pressures ranging up to a maximum of 5000 pounds. Capacity range is equal to that of regulators ten times its size. Although primarily designed for air and gases, this unit also can be furnished for liquid service. Its rugged strength is attributable to stainless-steel ports and the homogeneous structure of duraluinum from which it is made. Unique valve and seat construction was especially engineered for positive dead-end shut-off. It is instantaneous in its operation. Available for ⅛- and ¼-inch pipe size this unit was developed and proved in wartime service, where it was extensively employed in controlling the actuating medium on rockets and flame throwers. Full details, contained in Bulletin 940, are available on request.



Grove "Mity-Mite" Regulator

5—Regulator

Conoflow Corporation, 2100 Arch Street, Philadelphia 3, has announced its H-10 regulator.

Designed primarily for manual loading service in conjunction with pneumatic industrial instruments, this regulator combines a high degree of sensitivity with stability and freedom from "drift" errors.

On dead-end service, this regulator can be adjusted to hold any air pressure from 0 to 25 pounds constant within .05 of 1 pounds, regardless of vibration or upstream pressure variation.

Sensitivity and stability are due to the large area, nylon-inserted Neoprene diaphragm and to the floating design of plug and seat with its freedom from guiding surfaces which might become

more production in YOUR plant

When you clean small straight tubes of heat exchangers every *hour saved in downtime means extra dollars in plant throughput.* The Wilson TRIGGER POWER tube cleaner is designed with this thought in mind.

The Wilson TRIGGER POWER is the *only* tube cleaner with which it is economically practical to remove deposits from tubes that are *completely blocked*, without damage to tube walls and without need of removing the bundle from its shell.

Here are five reasons for this outstanding performance:

1. **The Trigger Power operates at high speeds (3500 RPM).**
2. **The Trigger Power has higher torque at any speed than any other tube cleaner.**
3. **Patented vibromatic attachment delivers 1900 blows per minute to the cutter bit, insuring an effective "bite."**
4. **An exclusive method introduces the scavenging agent — air, steam or water — directly to the cutter bit under pressure.**
5. **Complete finger-tip control of speed and power at all times.**

Illustration above shows easy one finger trigger control with fast action thumb lock.

These exclusive features assure you of the most thorough tube cleaning in all equipment for which the Trigger Power was designed.

You can now buy a Trigger Power Tube Cleaner from stock. Write for details today.

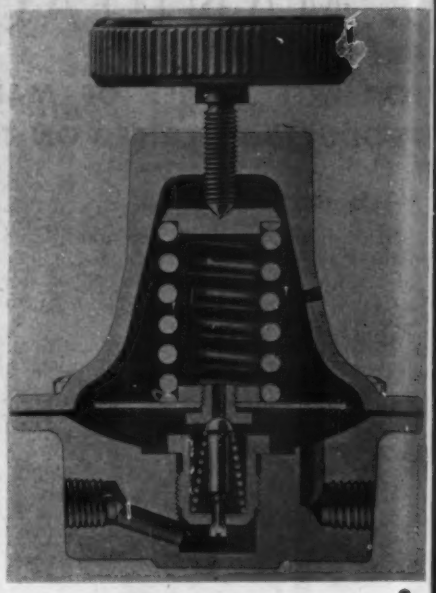
MODERN TUBE CLEANERS FOR THE PROBLEMS OF TODAY

wilson
PIPE AND TUBE CLEANERS EXCLUSIVELY

TW-701

THOMAS C. WILSON Inc.
21-11 44th AVENUE, LONG ISLAND CITY 1, NEW YORK

For copies of manufacturers' literature or additional information on products described, use mailing card, page 265.



Conoflow H-10 Regulator

a source of friction due to dirt accumulation.

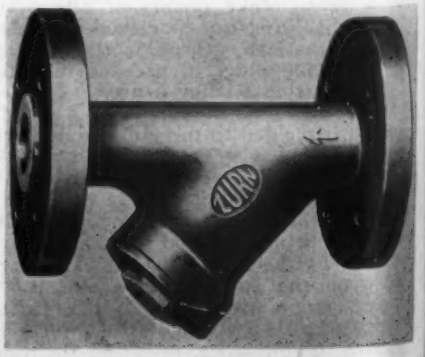
Compact and close-coupled, it is suited for mounting inside an instrument case or on a separately mounted panel. Body and spring housing are of forged brass. Plug and seats are highly polished stainless steel. All other steel parts are cadmium plated.

Regulator is provided with large diameter knurled plastic knob and fine thread screw requiring six or more turns for full range adjustment. Threaded spring housing and two lock nuts permit flush mounting or any thickness of panel up to 1-inch. Body tappings can be had in either ¼- or ⅛-inch standard pipe threads. Finish is dull black enamel. Size, 3 inches diameter by 4½ inches overall height.

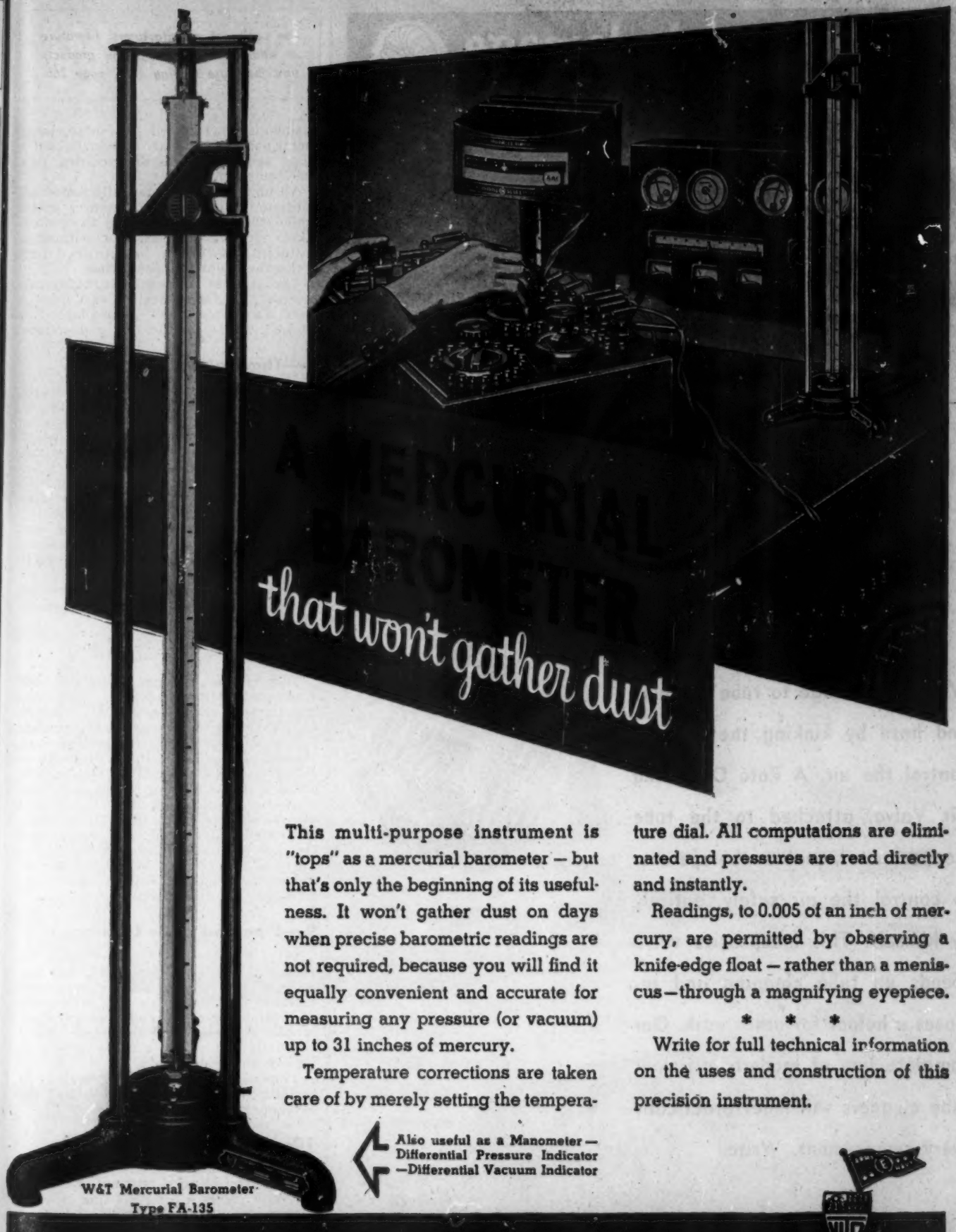
6—Strainer

J. A. Zurn Manufacturing Company, Erie, Pennsylvania, has perfected a "Y" strainer with a snug fitting strainer sleeve unit said to assure trouble-free operation on pipe line service.

The strainer sleeve is removable and is so designed that it cannot get out of place or vibrate when in use, a feature which enables the unit to be installed in almost any position on a pipe line. When service conditions require, the strainer



Zurn Strainer



This multi-purpose instrument is "tops" as a mercurial barometer — but that's only the beginning of its usefulness. It won't gather dust on days when precise barometric readings are not required, because you will find it equally convenient and accurate for measuring any pressure (or vacuum) up to 31 inches of mercury.

Temperature corrections are taken care of by merely setting the temperature dial. All computations are eliminated and pressures are read directly and instantly.

Readings, to 0.005 of an inch of mercury, are permitted by observing a knife-edge float — rather than a meniscus — through a magnifying eyepiece.

* * *

Write for full technical information on the uses and construction of this precision instrument.

W&T Mercurial Barometer
Type FA-135

Also useful as a Manometer — Differential Pressure Indicator —Differential Vacuum Indicator

WALLACE & TIERNAN PRODUCTS, INC.
BELLEVILLE 9, NEW JERSEY

Don't risk damage to tube cleaners and hose

Kinking tube cleaner hose to shut off air is poor practice at any time, especially now, when hose is a critical material. Besides ruining the hose, small hose particles may peel off and clog the motor.

Why risk damage to tube cleaners and hose by kinking the hose to control the air. A Roto Operating Air Valve, attached to the tube cleaner motor, enables the operator to control the air safely, entirely by himself. This inexpensive valve speeds up tube cleaning and releases a helper for other work. Our complete line of modern, efficient tube cleaners will meet practically every requirement. Write.

ROTO Division of ELLIOTT COMPANY
145 SUSSEX AVENUE - - - NEWARK 1, N. J.

For copies of manufacturers' literature or additional information on products described, use mailing card, page 265.

basket is magnetized for intercepting metal particles that are ruinous to valve seats and vital parts of operating pipe line equipment.

All units are hydrostatically tested according to the service pressures under which they will be required to operate. They are available with or without a cleanout plug, or can be furnished with a threaded blow-off connection.

The strainer is manufactured in cast bronze, steel, semi-steel or cast iron. A wide range of sizes is available for flanged, welded or threated connections.

7—Thermocouple Tubes

The Brown Instrument Company, 4498 Wayne Avenue, Philadelphia 44, has introduced an improved cast-iron thermocouple-protecting tuble, which has a uniform wall thickness to within 1/32 of an inch, with good surface finish. It is cast with both ends open, permitting positive support for the core at each end. One end is closed with a cast-iron filler rod, the opposite end being threaded for a 1-inch standard pipe. It has an inside diameter of 13/16 inches, outside diameter of 1¾ inches, wall thickness of 9/32 inches, minimum top thickness 9/32 inches, and weighs 4¼ pounds.

8—Crane

The Hughes-Keenan Company, 649 Newman Street, Mansfield, Ohio, has announced a crane, Model MC-8, which handles loads to 10 tons. It is a mobile full-swing boom crane, tractor mounted. Booms of standard lengths from 15 to 30 feet are furnished; MC-8 is especially adapted to use of long booms, will handle loads of nearly 2 tons at a 30-foot radius, 10 tons at 9 feet. Ball-bearing boom turntable and all gears and clutches run in oil, fully enclosed. Boom swing and hoist and load hoist are all independent actions, with separate controls and automatic brakes.

9—Pipe and Cable Locator

W. C. Dillon & Company, 5410 W. Harrison Street, Chicago 44, has announced the Stewart Cable Tester and Locator Combined, for use in location of shorts, crosses, grounds and wet spots in buried cables, and in simple operation tells just where a cable or pipe is buried, and now deep.

The unit is ruggedly built, weighs 22 pounds, and is compactly encased for easy portability.

10—Motors

Crocker-Wheeler Division of Joshua Hendy Iron Works, Ampere, New Jersey, now offers a complete line of alternating-current, squirrel-cage, protected type motors from 1 to 200 horse power, rated 40 C rise, full-load, continuous duty, with a 15 percent service factor. These motors provide full protection against dripping liquids and other foreign matter.

Sizes built in NEMA standardized frames, 203 to 326 inclusive, have no openings in the frame or shields above

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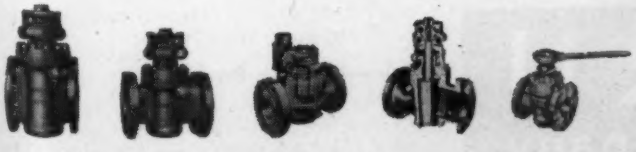
A turn to the left lifts the plug; a turn to the right restores it to perfect adjustment in the body. In the toughest kinds of service, HAMER Plug Valves are ready for instant, easy operation — always!



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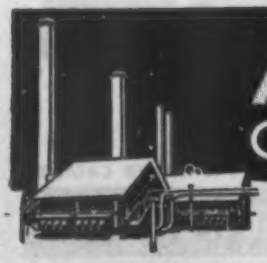

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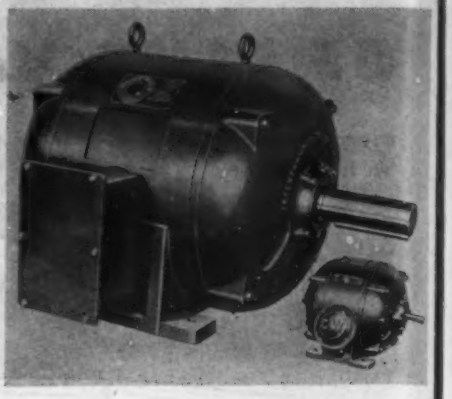

Two extremes of Crocker-Wheeler Protected Type Motors

the horizontal center line. NEMA standardized frames 326 to 505 as well as three, newly added larger sizes are basically the same in construction with the addition of two shielded, air-exhaust openings in the upper half of the frame. The design of these openings precludes any possibility of falling liquids, etc., entering the motor.

The company's patented centrifugal bearing seal is used in all ball-bearing machines. This seal permits the use of softer grease for better lubrication and longer bearing life.

Alucast rotors, in which the bars, fans and end rings are cast in one operation from aluminum alloys, is employed for sizes 203 to 404 inclusive. Rotors of larger sizes have copper bars with brazed-on fans and end rings. Stator coils of all sizes are protected by vinylastic insulation.

11—Metal Spray Booths

Metallizing Engineering Company, Long Island City 1, New York, has issued Bulletin 43-A, on its line of metal spray booths for handling dust from metal spray work. Included is a lathe exhaust unit which is mounted on the lathe carriage and moves with it.

12—Flow-Rate Measurement

Fischer & Porter Company, Hatboro, Pennsylvania offers the third, revised edition of "A New Era in Flow Rate Measurement," which discusses and illustrates the advantages of the rotameter for flow-rate measurement.

13—Vibration Control

The Korfund Company, 48-15 Thirty-Second Place, Long Island City 1, New York, is distributing a 12-page bulletin on the effects of vibration on plants, equipment and personnel, and methods of controlling vibration.

14—Needle Bearings

The Torrington Company, Torrington, Connecticut, announces publication of a new 153-page manual—a combined catalog and engineering and application data reference volume for designers and engineers, entitled "Torrington Needle Bearings," and listed as Edition No. 32. A separate section on application data, illustrated with cross-section drawings,

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shows a wide variety of uses. Included in the informatory data are specifications and tolerances; load capacities; design factors; installation and inspection data; various standards, and a wealth of similar material. The manual is fully indexed for handy reference and has many tables, formulae and illustrations that clarify the technical data and serve as a valuable guide for the engineer and production executive.

15—Welding

The Lincoln Electric Company, 12818 Coit Road, Cleveland 1, Ohio, has released new and revised literature giving details of the training courses it offers in welding and welding engineering.

16—Vacuum Cleaners

Allen Billmyre Company, 431 Fayette Avenue, Mamaroneck, New York, has issued Bulletin F-4 on its portable vacuum cleaners. Models shown are designed to fit the needs of all types of industrial and commercial buildings.

17—Protective Coatings

Preferred Utilities Manufacturing Corporation, 1860 Broadway, New York 23, has available a booklet "New Approaches to Surface Protection," a technical discussion of the properties of heat-resistant coatings. The same company's Bulletin No. 925 is a non-technical discussion of the properties of its protective coatings for surfaces exposed to high temperatures.

18—Forging Terms

Kropp Forge Company, 5301 West Roosevelt Road, Chicago 50, is distributing a 24-page "Glossary of Forging Terms" as an aid to users and buyers of forgings in better understanding forging practice.

19—Packing

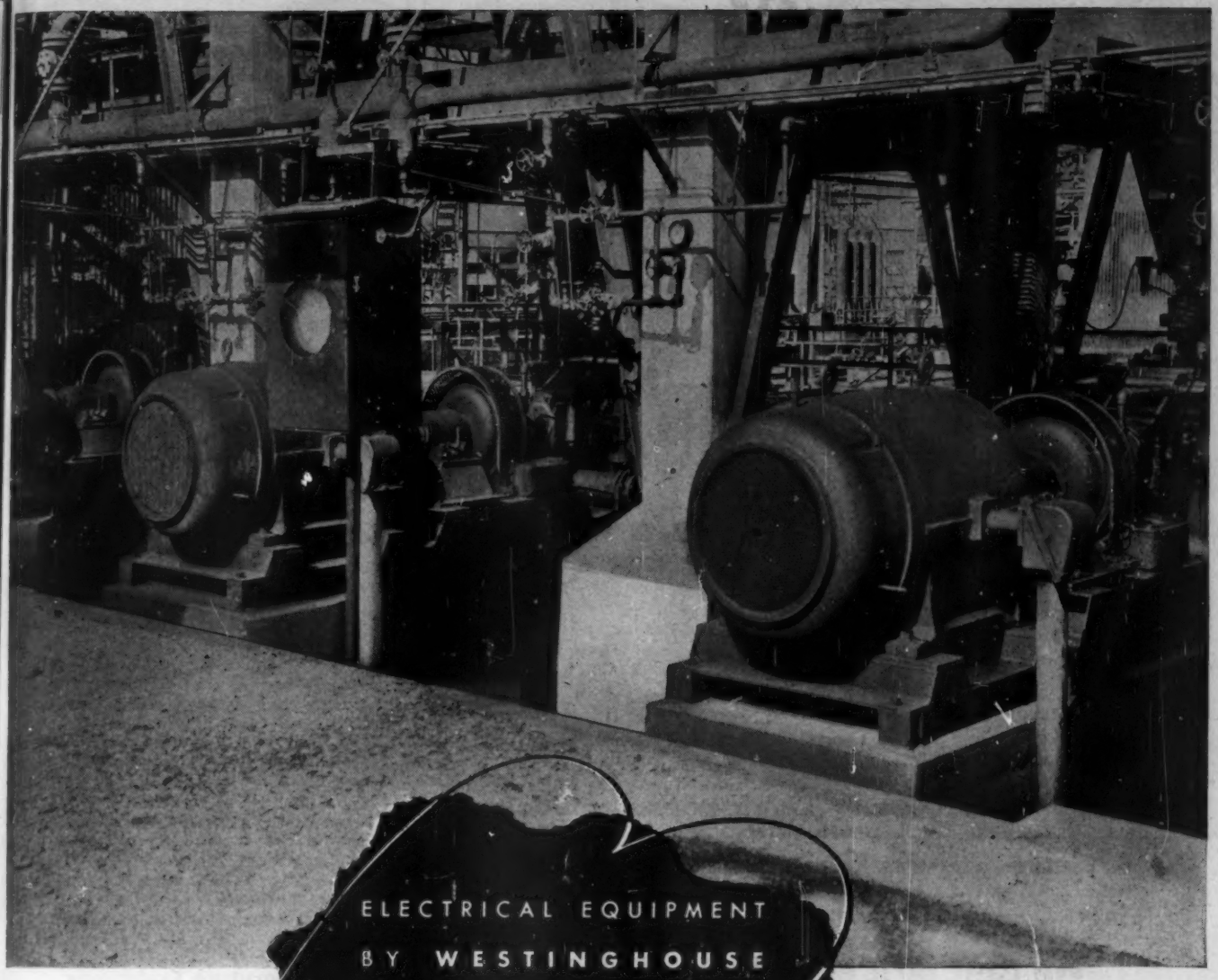
The Weatherhead Company, 300 East 131st Street, Cleveland 8, Ohio, is distributing a bulletin which gives details on its T-Ring hydraulic packing which it claims does away with extrusion damage. Developed for aircraft hydraulic service, the packing is being offered for general industrial use in reciprocating, static and special applications.

20—Tachometer

Herman H. Sticht Company, 27 Park Place, New York 7, has released Bulletin 750, which describes a new universal type hand tachometer, with five ranges. The instrument is imported from Switzerland.

21—Barometric Condensers

Ross Heater & Manufacturing Company, 1419 West Avenue, Buffalo 13, New York, is distributing Bulletin No. 4509, "Parallel-Flow Barometric Condensers." This file-size bulletin offers useful data on the use of parallel-flow type barometric condensers as intercondensers and aftercondensers in connection with steam-jet ejectors. The



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Ross Non-Clogging Spray Nozzle is explained as a vital part of the unit. Engineering data covers duty, temperature rise, terminal difference, condensing-water requirements and a table for selecting the correct size unit. Complete dimensions and weights are accompanied by drawings.

22—Process Equipment

Ingersoll-Rand, 11 Broadway, New York 4, has available a new 16-page catalog entitled "Equipment for Chemical and Process Plants." It is illustrated with views of the company's products in service, and covers items from compressors, pumps, and engines to air tools. Several cross sections and schematic drawings show the workings of ejectors, barometric condensers, and the process of water-vapor refrigeration.

23—Deaeration

Elliott Company, Jeannette Pennsylvania, has issued a 20-page booklet which is a restatement of the science of deaeration and its effectiveness in controlling corrosion. Illustrated with graphs and photographs, the booklet describes corrosion in general and the part deaeration plays in checking it. A table shows the derivation of the pH factor, and a graph indicates the effect of pH on the rate of corrosion. Other graphs cover solubility of oxygen and carbon dioxide in water at various temperatures, and solubility of the oxygen component of air in distilled water at various temperatures and pressures.

24—Temperature Exchanger

Bird-White Company, 3119 West Lake Street, Chicago 12, has issued Bulletin No. 12, on a new temperature-exchanger after-cooler for compressors. It includes engineering drawings and complete specifications with minimum and maximum capacities of the models available.

25—Gas Turbines

Elliott Company, Jeannette, Pennsylvania, has published a booklet on gas turbines, "The Gas Turbine Power Plant—Now a Reality," which traces the development of the gas turbine. "A look into the future foresees the gas turbine as a principal form of power for ships, locomotives, and electrical generating plants, both utility and industrial. The gas turbine may even be adapted to buses, trucks, and automobiles—offering a real challenge to engineers," says the booklet.

26—Extraction Steam Heaters

The Griscom-Russell Company, 285 Madison Avenue, New York 17, has available Bulletin No. 278 which describes and illustrates extraction heaters of both horizontal and vertical types for high, medium and low pressures. Numerous cross-section diagrams graphically explain operation of well as constructions. Described are the G-R exclusive visible pressure seal of breech-block heads, self-adjusting compres-

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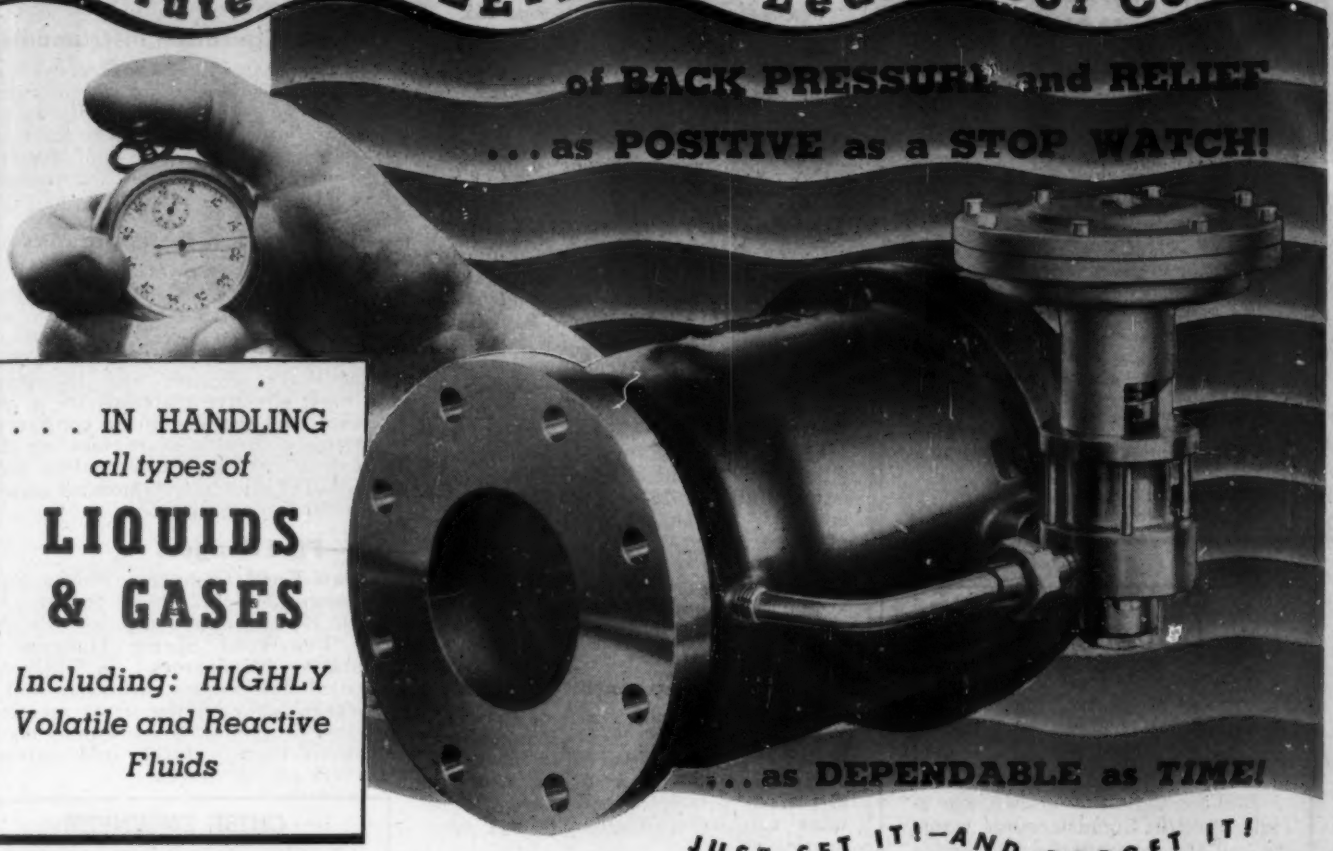

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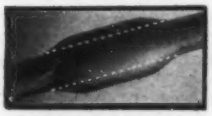
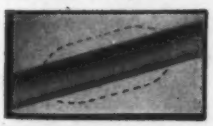


EXPANDS TO OPEN



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sion ring gaskets, partition pass plates to prevent leakage between passes without use of stay bolts, enveloping steam baffle which permits cross-over temperatures, and removable air baffle with sub-cooling action.

27—Engine Temperature Control

Evans Products Company, Fullerton at Greenfield, Detroit 27, Michigan, is distributing a booklet which in question-and-answer form details the advantages of its thermo-control fan for automatic precision temperature control of coolants in internal-combustion engines.

28—Demineralizers

Cochrane Corporation, 17th Street and Allegheny Avenue, Philadelphia 32, has issued Bulletin 4181—'Cochrane Demineralizers," which describes the process of preparing clear water, the equivalent of commercially distilled, by iron exchange. The text is in simple language, accompanied by illustrations and chemical reactions of the ion-exchange process.

29—Water Separator and Filter

Flotrol Systems, Inc., 385 Gerard Avenue, New York 51, has available a bulletin descriptive of its "Excel-so" separator, a unit that removes water and dirt from petroleum products. It contains valuable performance and engineering data.

30—Control Valves

Hammel-Dahl Company, 243 Richmond Street, Providence 3, Rhode Island, has issued Catalog V I on automatic control equipment. This handsome booklet gives descriptions with cut-away illustrations of the company's standard control valves, and includes data on special engineering services offered.

31—Gaskets

U. S. Gasket Company, 1960 Pierce Avenue, Camden, New Jersey, is distributing a folder giving construction and specification data on Ajax spiral-wound gaskets for boiler accessory gaskets; self-centering gaskets; flange gaskets with solid steel reinforcing ring, and manhole gaskets with wire guide, in pressure groups up to 3500 pounds.

32—Stainless Steel

Republic Steel Corporation, 3100 East 45th Street, Cleveland 4, Ohio, has just produced a 32-page booklet, Adv. 430, entitled, "In War . . . In Peace, Republic Enduro Stainless and Heat-Resisting Steels." Generously illustrated with photographs, it graphically tells of the many things "Enduro" did in the war effort. It emphasizes how these wartime applications can be readily translated into peacetime terms.

33—Thermocouples

Wheelco Instruments Company, Chicago, 7, has issued a new edition of its Thermocouple Data Book and Catalog. Containing 32 pages and designated Bulletin S2-6, it gives information on selection of proper thermocouples and carries installation aids. It describes and lists prices and recommendations on thermocouples, thermocouple wire, lead wire, heads, connectors, plug and socket assemblies, insulators and protecting tubes.

34—Refrigeration Instruments

Taylor Instrument Companies, Rochester 1, New York, has issued Catalog No. 300, 36 pages dealing with application of control instruments to the refrigeration field. Illustrated and described are instruments available for refrigeration purposes.

35—Corrosion-Resistant Masonry

The U. S. Stoneware Company, Akron 9, Ohio, is distributing Bulletin 810, a Material and Construction Manual on Corrosion-Resistant Masonry. The section on materials is designed to provide the engineer with information on most effective materials for a given service, and the section on construction contains a wealth of engineering data, design details and construction aids—much of it applicable to general masonry construction problems.

36—Pipe Hangers

Blaw-Knox Company, Power Piping Division, 342 Madison Avenue, New York 17, has issued Catalog No. 2026, on "Functional Spring Hangers and Vibration Eliminators." In addition to detailed descriptions, drawings and engineering data on the items mentioned in the caption, this handsome booklet contains much valuable information of general piping design.

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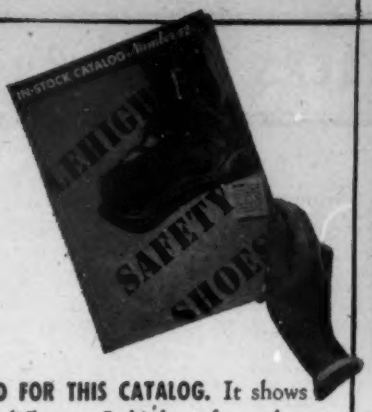

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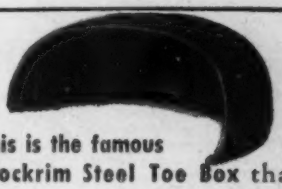

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***Detailed Information on Advertisers' Products or Services in 1944 Edition of The Refinery Catalog**

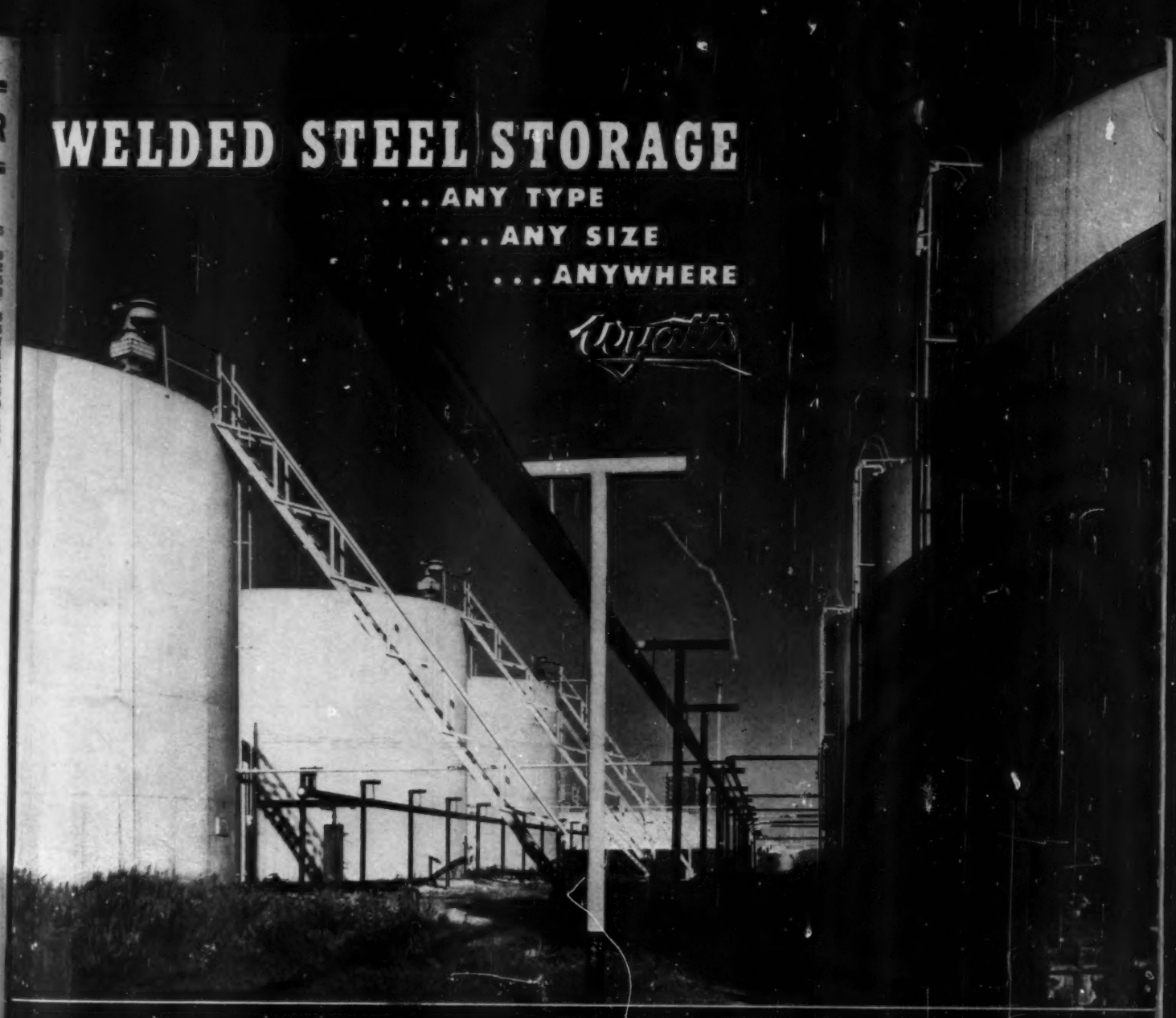
WELDED STEEL STORAGE

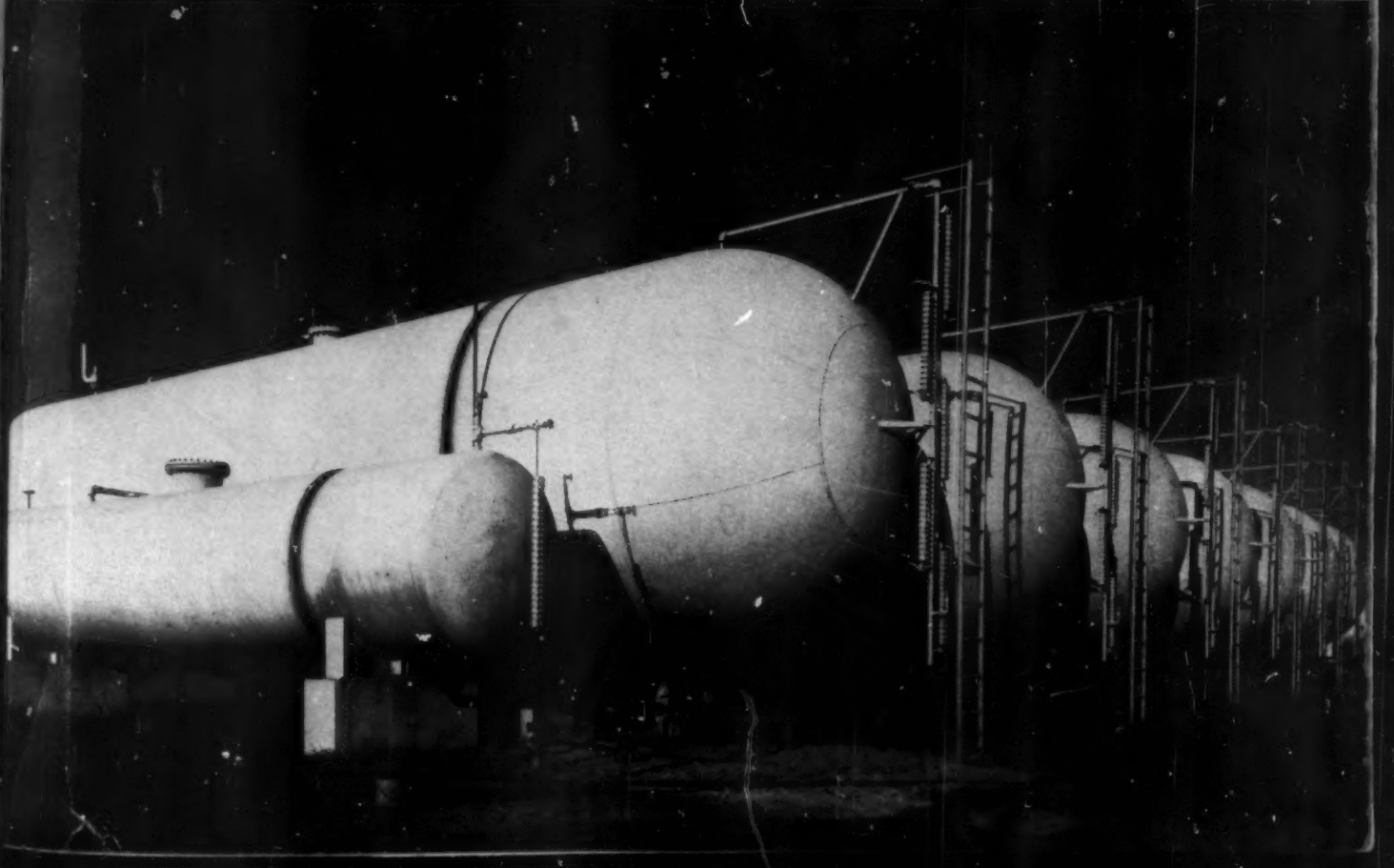
. . . ANY TYPE

. . . ANY SIZE

. . . ANYWHERE

Wyatt





HOME OF THE SWING JOINT

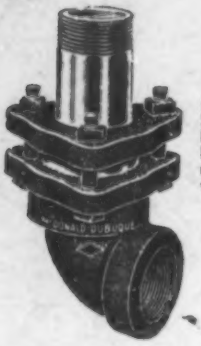


Plate 813 — Standard Swing Joint (Single). Iron body, bolted iron gland, bronze ferrule. Careful machining keeps down wear. ¾" to 12".

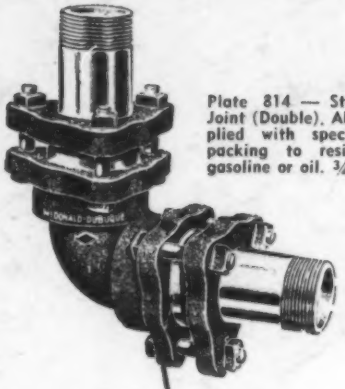


Plate 814 — Standard Swing Joint (Double). Abundantly supplied with special McDonald packing to resist action of gasoline or oil. ¾" to 12".

Plate 898 — All-Bronze Swing Joint—Screw Gland (Double). Well made and time-tested, for use where clearance space is limited. 2", 2½", 3".

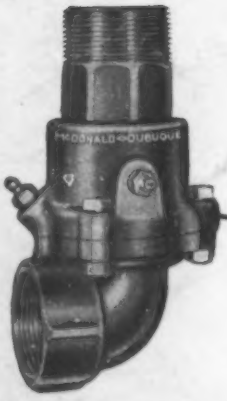


Plate 983—The McDonald Master (Single). Finest of all swing joints. Incredibly long life, unbelievable ease of operation. All-brass construction. 1½", 2", 2½", 3".

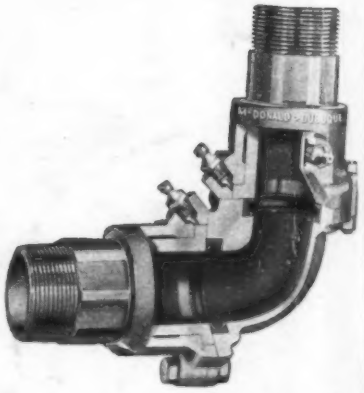


Plate 984—McDonald Master (Double). Grease-gun lubrication insures lifetime service. A master creation of the organization that originated swing joints. 1½", 2", 2½", 3".

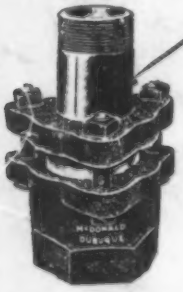


Plate 889—Straight Swing Joint — for use where an angle swing joint is not advisable; otherwise similar to Plate 813. 1½" to 4".

Plate 897—All Bronze Swing Joint — Screw Gland (Single). Carefully machined for long life. Guaranteed satisfactory performance. 2", 2½", 3".

Plate 823—One of a series of Special All-Bronze Swing Joints used where flexible connection is desired on small lines. 90° Single. ¾", 1", 1¼".

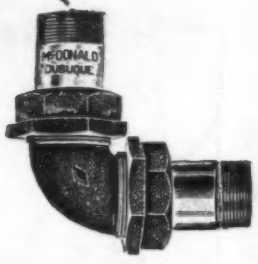


Plate 824 (Double)—Another in the series of Special All-Bronze Swing Joints. Turns freely without leaking. Packing resists action of gasoline and oil. ¾", 1", 1¼".

The swing joint was born in the plant of A. Y. McDonald Mfg. Co. and reaches its highest state of development in the current McDonald line. When buying from McDonald—the Home of the Swing Joint—you get the benefit of unmatched experience in swing joint design and construction. There's safety and economy in such a choice!

A. Y. McDONALD MFG. CO.

"THE HOME OF THE SWING JOINT"

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